From: Chris Bruns
To: DLNR.FW.HCP
Cc:
Subject: [EXTERNAL] Avoid bat take as required by law - stop trying to fit a round peg in a square hole
Date: Tuesday, September 29, 2020 7:27:22 AM
Attachments: April 17th, 2020 Attorney Charles M. Tebbutt Letter and AES Response (1).pdf
Na Pua Makani Minute Order 11 Contested Case Hearing Officer Recommendation to BLNR.pdf

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Dear DOFAW,

For the sake of the endangered Hawaiian hoary bat and humans living in residential areas near (extremely lucrative) wind turbines, please stop allowing turbines to operate at night. I am submitting this comment email for your reference at your September 30 ESRC meeting discussing the bat white paper (https://dlnr.hawaii.gov/wildlife/esrc/meeting-archives/).

Please see attached letter on behalf of Kahuku residents to Na Pua Makani Wind Farm in relation to the nigh time shut down. We live three miles downwind from the existing Kahuku Wind Farm and (as is the case 4.2 miles from wind turbines in Wisconsin), my wife is suffering from disturbance of her sleep when the turbines are on (her sleep is totally normal when she rents a room five miles away from turbines in Waialua/Mokuleia, and when she is able to travel away for work) - nothing we have done (building a soundproof "crypt" in our garage with seven layers of sheetrock with Green glue compound to avoid resonance (see nonapua.com for updates), antidepressants and sleeping pills, no - the only way she gets normal sleep is by getting away from the turbines. The low-frequency 1 - 3 Hz sound pressure pulses are essentially air pressure pulses at our 3-mile distance - which can't be blocked with structures or ear plugs or anything we've tried. Turbines shouldn't even be on at night because the wind farm can, without question, afford to shut down at night to avoid killing endangered bats. Because it takes 10 years to get a wind farm removed and the new Na Pua Makani Wind Farm would operate for 20 years, the Na Pua Makani Wind Farm will certainly be shut down because it is a public health hazard and 10 years of litigation is better than facing 20 years of turbine operation - four of its turbines are on State land, so the State will share liability. The turbines are so close to residents and schools, we anticipate the County will declare Na Pua Makani a public health hazard and have the turbines shut down, or the County and State will buy out the wind farm (valued around $100 million if it's able to operate at night (without the threat of nuisance noise civil litigation - not sure how much the civil effort will help negotiations about the buyout price), but only costing taxpayers $50 million if it is not able to operate at night, as per HRS 195D to protect bats (see Minute Order 11 recommendation the BLNR deny Na Pua Makani ITL - after which the BLNR drew up excuses for disregarding the best available science and the law - putting the law itself at risk as the general public, in their desperation, does everything possible to get the turbines shut down).

Please don't continue to try to contort yourselves to try to pretend it's ok to allow wind turbines to operate at night in Hawaii. The proposed bat white paper is full of arbitrary attempts to justify allowing night operation of turbines - such as choosing to use bat core area from macadamia nut orchards in rain forest - rows of trees, rather than more applicable pasture, native dry and mesic forest, low-density developed landscape, where bats flew over native forest to feed in pasture, gulches, and low-density developed areas. I guess if mitigation is removing native forest and installing mac nut groves your choice makes sense. Obviously, we all want to fund projects to conserve native forest - but don't sell out the bats and the people who have lived for generations in areas where you're now reviewing wind turbine licenses to get money for your other projects. The wind farms can afford to shut down at night - they will still be more profitable than mainland wind farms with the Hawaii nighttime shutdown.

Thank you,
Christopher Bruns, Sunset Beach, Oahu

Law Offices of Charles M. Tebbutt, P.C.
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Ph: 541-344-3505 Fax: 541-344-3516

April 17, 2020

Via First Class Mail:

Mark Miller
Chief Operating Officer, US Generation
The AES Corporation
4300 Wilson Boulevard, 11th Floor
Arlington, VA 22203

Mike Cutbirth
Na Pua Makani Power Partners, LLC
2020 Alameda Padre Serra, Suite 105
Santa Barbara, CA 93103

RE: Na Pua Makani Wind Project

Dear Sirs and Madams:

On behalf of Ku Kia'i Kahuku,[1] this letter is to put you on notice of the significant and unreasonable health risks threatened by locating the Na Pua Makani Wind Project (the "Project") in close proximity to the Kahuku community. As you should be aware, published scientific literature concludes that the sound characteristics of wind turbines like those proposed for the Project may lead to serious adverse health effects to nearby residents. Failure to investigate and mitigate these risks puts the health and well-being of the Kahuku community in jeopardy – especially the community's children, who are most susceptible to the foreseeable injuries presented by the Project. Without further site-specific research into the adverse health effects threatened by the Project's wind turbines – which, as proposed, are the largest onshore turbines in the United States – any decision to move forward with the Project is tortious, reckless, and at the very least negligent, and Na Pua Makani Power Partners will be liable for all reasonably foreseeable damages.

Uniquely situated to endure the current impacts of climate change, Ku Kia'i Kahuku recognizes and supports the need for safe, affordable, and renewable energy. Achieving these goals, however, does not require the sacrifice of the Kahuku community's health and well-being by placing massive wind turbines in dangerously close proximity to residents. With existing turbines in the community, the addition of larger turbines increases the risk to the community.

[1] Ku Kia'i Kahuku's mission is protect our keiki, kupuna and our community from developers in our moku by supporting the wellbeing and country lifestyle of Koolauloa and strengthening our ohana to be proactive in the decision-making process of proposed development within our moku.

It is well known that environmental noise is a serious public health concern.[2] Industrial wind turbines are particularly known to affect nearby residents' health and quality of life.[3] While the current body of science acknowledges that wind turbines cause annoyance and sleep loss, as discussed below, emerging studies show the adverse health effects from the low frequency sound and infrasound from larger wind turbines may lead to additional health effects, such as headaches, nausea, mental impairment, and even cardiovascular problems.[4] Furthermore, the proposed Project will cause a significant diminution in property value for all of the nearby residents.

First, the unique characteristic of wind turbine noise, characterized as the "Wind Turbine Signature," is a constant, rhythmic pulse created by amplitude modulations.[5] These swishing pulses become more dominant during the night when residents are attempting to sleep and increase in magnitude when multiple turbines in the same vicinity propagate in phase.[6] Additionally, the amplitude modulations and sounds increase in proportion to ambient wind speed and become even more prominent under certain meteorological conditions.[7] Numerous scientific studies have shown that the pulsating noise generated by wind turbines is a major factor contributing to annoyance.[8] The evidence shows that when wind turbine noise exceeds the tolerable limit, ranging from 35 dB to 40 dB, a significant percentage of residents in close proximity to wind turbines suffer annoyance, sleep loss, and a decreased quality of life.[9]

Second, the growing size of wind turbines has raised additional concerns as the sound characteristics of these larger wind turbines shift to even lower frequencies and more prominent infrasound.[10] Studies show that even inaudible sound from large wind turbines contribute to adverse health effects.[11] Large wind turbines also operate at lower revolutions per minute (rpm) which, combined with the lower frequency and infrasound, places them into the range of maximum nausogenicity identified by the United States Navy.[12] Currently, scientists are urging caution with growing wind turbine sizes as

[2] Nissenbaum, M., et al. Effects of Industrial Wind Turbine Noise on Sleep and Health. 2012. *Noise Health*; 14:237-243.

[3] *Id.*

[4] Bolin, K., et al. Infrasound and Low Frequency Noise from Wind Turbines: exposure and health effects. 2011. *Environ. Res. Lett.* 6:035103.

[5] Van den Berg, G., et al. The Beat is Getting Stronger: the Effect of Atmospheric Stability on Low Frequency Modulated Sound of Wind Turbines. 2005. *J. Low. Freq. Noise Vib. Active Control*. 24:1-24.

[6] *Id.*

[7] *Id.*

[8] *Id.*

[9] Michaud, D., et al. Exposure to Wind Turbine Noise: Perceptual Responses and Reported Health Effects. 2016. *J. Acoust. Soc. Am.* 139: 1443-54.

[10] Moller, H. and Pedersen, C. Low Frequency noise from Large Wind Turbines. 2011. J. *Acoust. Soc. Am.* 129:3727-44.

[11] Lichtenhan, J. and Salt, A. Amplitude Moduluation of Audible Sounds by Non-Audible Sounds: Understanding the effect of Wind Turbine Noise. 2013. *Proc. Mtgs. Acoust.* (19):040064; Salt, A. and Huller, T. Responses of the Ear to Low Frequency Sound, Infrasound and Wind Turbines. 2010. *Hear. Res.* 268:12-21.

[12] Schomer, P.D., et al. A Proposed Theory to Explain some Adverse Physiological Effects of the Infrasonic Emissions at some Wind Farms Sites. 2013. *Proceedings on the 5th International Conference on Wind Turbine Noise.* August 2013. Available at:

sounds with prominent infrasound and low frequency impact human health and well-being to a greater extent than the sounds from smaller wind turbines.[13]

Recent wind farm studies, such as the Cape Bridgewater and Falmouth, MA studies, indicate that wind turbines up to 2.0 MW create significant pressure pulsations that one court found "affects injuriously the health or comfort of ordinary people in the vicinity to an unreasonable extent."[14] In the 2014 Cape Bridgewater study, commissioned by Pacific Hydro, scientists examined the effects of multiple 2.0 MW turbines on residents located within 3000 feet of the turbines.[15] These residents reported experiencing severe discomfort from the low frequency noise and distinct pressure that could be detected in various parts of the body.[16] Additional symptoms included headaches, ringing in the ears, heart racing, and an overall sensation of "heaviness."[17] These impacts, however, are not isolated as communities around the country are reporting more and more adverse health impacts from large wind turbines.[18]

Here, the Project's proposed 3.4 MW turbines are significantly larger than the Cape Bridgewater and Falmouth, MA studies, and, in fact, are larger than any onshore wind turbines examined in a published scientific study. Compounding the problem, the wind turbines will be located at a much closer proximity than recent studies have examined, less than 1750 feet from the residences and elementary school, and less than 800 feet from farms. The Project's own Supplemental Final Environmental Impact Statement conclusively states that its wind turbine noise will exceed the requirements of ANSI S12.9 Part 4, but fails to propose any research into the expected and predictable health impacts or any possible mitigation measures to reduce the risk of irreparable injury. As the largest onshore wind turbines, Nu Pua Makani knows, or at least should know in the exercise of reasonable diligence, that the proposed placement of the 3.4 MW turbines will cause more severe health impacts than any other turbine previously studied.

The Project's proposed location will cause residents of Kahuku to lose millions of dollars in property value, which Na Pua Makani Wind has heretofore failed to address. Economic assessments of the effects of wind farms on property value have repeatedly and consistently shown property value losses when turbines are located within *miles* of

https://stopthesethings.files.wordpress.com/2013/09/schomer-et-al-windturbine-noise-5th-int-conference-aug-2013.pdf.

13 Bolin, K., et al. Infrasound and Low Frequency Noise from Wind Turbines: exposure and health effects. 2011. *Environ. Res. Lett.* 6:035103.

14 The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm, prepared for Energy Pacific Ltd. November 26, 2014. Available at: http://www.pacifichydro.com.au/files/2015/01/Cape-Bridgewater-Acoustic-Report.pdf; *see also Town of Falmouth v. Town of Falmouth Zoning Bd. of Appeals*, 2017 Mass. Super. LEXIS 144, *18, 34 Mass. L. Rep. 408, 2017 WL 4479202.

15 *Id.*

16 *Id.*

17 *Id.*

18 Spencer, J. Wisconsin Wind Turbines Declared Health Hazard. November 8, 2014. *Michigan Capitol Confidential*. Available at: https://www.michigancapitolconfidential.com/20690; Whitaker, J. More than 100 Residents Sue Arkwright Project Developers. September 26, 2019. Observer Today. Available at: https://www.observertoday.com/news/page-one/2019/09/more-than-100-residents-sue-arkwright-project-developers/.

homes. Courts have also acknowledged and accepted property loss values up to 55% from wind farms.[19] A 2014 London School of Economics study showed that wind farms decreased property values by approximately 12% when the turbines are located within 2 km (approximately 1.25 miles) of the home.[20] Taking into account the 578 homes in Kahuku and the median home value of $516,300, Na Pua Makani Wind's Project will likely cause at least $35,810,568 in property value losses.

The above information is but a sampling of the negative consequences from large wind power installations. Other concerns include stray voltage from inadequate electrical engineering, a problem of particular concerns in micro-climates such as Kahuku's that is often quite wet. This notice is provided to you as a warning that the proposed Na Pua Makani Wind Project is likely to cause irreparable injury to human health and property. In light of these consequences, Ku Kia'i Kahuku requests that you forego construction of the proposed Na Pua Makani Wind Project until further scientific research is done and conclusively shows that the proposed project will not adversely affect the health and property value of the residents of nearby Kahuku. If you choose to proceed with the project, please be on notice that such decisions may result in future proceedings against you. As the size of wind turbines grow throughout the country, an increasing number of nuisance claims continue to move forward through the court system. Only one successful nuisance claim would eliminate the economic benefits of rushing forth with the proposed Project. More importantly, the damage inflicted on the Kahuku community and members of the public would be immeasurable.

Describing the experience of the failed wind farm in Falmouth, MA, Congressman Thomas McClintock stated, "The townspeople couldn't bear the noise, the constant flickering of light as 400-foot windmills turned and property values plunged 20 percent. I wonder how that squares with the bright picture you've painted."[21] Over the past three decades, research continues to reveal new and alarming impacts to all aspects of human health from industrial wind turbines. Ku Kia'i Kahuku urges you learn from the past failed wind turbine projects and to halt construction of the Na Pua Makani Wind Project to undertake the necessary scientific research to ensure that current and future generations of Kahuku are free to live and enjoy their land free from exposure to harmful environmental noise of wind turbines.

In addition to the above problems, the Kahuku community is being asked to bear a disproportionate impact from the wind turbines in order to send power to 7,000 homes in other areas of Oahu as the 578 homes in Kahuku suffer. While climate change requires action to alleviate the impacts of a fossil fuel-based energy system, individual communities should not be sacrificed in the process. At the very least, AES Corp. and Na

[19] Clemente, J. Do Wind Turbines Lower Property Values? September 23, 2015. *Forbes*. Available at: https://www.forbes.com/sites/judeclemente/2015/09/23/do-wind-turbines-lower-property-values/#4adf4c6f48cb.

[20] *Id.*

[21] Cole, B. Falmouth Wind Turbines Called 'Disaster' on National Stage. February 7, 2019. *The Falmouth Enterprise*. Available at: https://www.capenews.net/falmouth/news/falmouth-wind-turbines-called-disaster-on-national-stage/article_7fb950b0-2758-54b3-a61b-1a26ce9d0906.html.

Pua Makani Power Partners, LLC should provide the opportunity for people who do not wish to be on the receiving end of such disproportionate impact to be bought out at a fair market price using the assumption that no wind turbines were present.

My clients are willing to work with you to ensure the safety of Kahuku. We look forward to your response and welcome further dialogue.

Sincerely,

Charles M. Tebbutt

Amanda Steiner
Terrell Marshall Law
Group PLLC
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Cc:

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AES
we are the energy

May 7, 2020

Via U.S. Mail

Charles M. Tebbutt, Esq.
Law Offices of Charles M. Tebbutt, P.C.
941 Lawrence Street
Eugene, OR 97401

Re: Na Pua Makani Wind Project

Dear Mr. Tebbutt:

Thank you for your letter dated April 17, 2020. Throughout the entire project process, AES has worked with many consultants, engineers, and various governmental agencies, including the State of Hawaii Department of Health, to ensure that the Na Pua Makani wind project is developed in full compliance with all applicable laws and permit conditions, including those relating to the health and safety of the community. We look forward to completing the project and are proud to be assisting the State of Hawaii with achieving its clean energy goals by harnessing the island's wind resources and converting it into clean, sustainable energy, providing increased energy independence from imported oil and saving some 70,000 tons of CO_2 annually from being emitted.

Mark Miller
Chief Operating Officer, AES US Generation

cc:

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BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

IN THE MATTER OF A Contested Case Hearing Re Final Habitat Conservation Plan and Incidental Take License for the Na Pua Makani Wind Energy Project by Applicant Na Pua Makani Power Partners, LLC; Tax Map Key Nos. (1) 5-6-008:006 and (1) 5-6-006:018, Koolauloa District, Island of O'ahu, Hawaii.	Case No. BLNR-CC-17-001 MINUTE ORDER NO. 11; CERTIFICATE OF SERVICE

MINUTE ORDER NO. 11

Attached are the Hearing Officer's Recommended Findings of Fact, Conclusions of Law, and Decision and Order.

The Board of Land and Natural Resources, by a separate minute order, will provide the opportunity for any party in this case to file written exceptions to the Recommended Findings of Fact, Conclusions of Law, and Decision and Order.

DATED: Honolulu, Hawai'i, November 1, 2017.

YVONNE Y. IZU
Hearing Officer

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

IN THE MATTER OF A Contested Case Hearing Re Final Habitat Conservation Plan and Incidental Take License for the Na Pua Makani Wind Energy Project by Applicant Na Pua Makani Power Partners, LLC; Tax Map Key Nos. (1) 5-6-008:006 and (1) 5-6-006:018, Koolauloa District, Island of O'ahu, Hawaii.	Case No. BLNR-CC-17-001 CERTIFICATE OF SERVICE

CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of Minute Order No. 10 was duly served upon the following parties, by Hand Delivery, U.S. Mail, postage prepaid, or electronically, at the addresses below:

Yvonne Y. Izu
Hearing Officer
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DATED: Honolulu, Hawai`i, November 1, 2017.

KATHERINE CULLISON
Department of Land and Natural Resources

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAII

IN THE MATTER OF A Contested Case Hearing Re Final Habitat Conservation Plan and Incidental Take License for the Na Pua Makani Wind Energy Project by Applicant Na Pua Makani Power Partners, LLC; Tax Map Key Nos. (1) 5-6-008:006 and (1) 5-6-006:018, Koolauloa District, Island of Oʻahu, Hawaii.	)	Case No. BLNR-CC-17-001 HEARING OFFICER'S RECOMMENDED FINDINGS OF FACT, CONCLUSIONS OF LAW, AND DECISION AND ORDER

HEARING OFFICER'S RECOMMENDED FINDINGS OF FACT, CONCLUSIONS OF LAW, AND DECISION AND ORDER

The Hearing Officer recommends that the Board of Land and Natural Resources ("Board") adopt the following Findings of Fact (FOF), Conclusions of Law (COL), and Decision and Order (D&O) (collectively, "Recommendation"), based on the records maintained by the Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) on contested case number BLNR-CC-17-001, A Contested Case Hearing Re Final Habitat Conservation Plan and Incidental Take License for the Na Pua Makani Wind Energy Project by Applicant Na Pua Makani Power Partners, LLC; Tax Map Key Nos. (1)5-6-008:006 and (1)5-6-006:018, Ko`olauloa District, Island of O`ahu, Hawai`i, and the witness testimonies and exhibits presented and accepted into evidence.

If any statement denominated a COL is more properly considered a FOF, then it should be treated as a FOF, and conversely, if any statement denominated a FOF is more properly considered a COL, then it should be treated as a COL.

FOF and COL proposed by the parties to this contested case that are not incorporated in this Recommendation have been excluded because they may be duplicative, not relevant, not material, taken out of context, contrary (in whole or in part) to the found facts, an opinion (in whole or in part), contradicted by other evidence, or contrary to law. Parties' proposed FOF and COL that have been incorporated may have minor modifications or corrections that do not substantially alter the meaning of the proposed finding or conclusion.

I. FINDINGS OF FACT

A. The Parties

1. Na Pua Makani Power Partners, LLC ("Applicant" or "NPM") is a Delaware limited liability company and the Applicant of the Habitat Conservation Plan ("HCP") and Incidental Take License ("ITL") in the above-captioned matter.

2. Keep the North Shore Country ("KNSC") is a grassroots, volunteer-based North Shore non-profit, formed in 2006, to preserve, protect and enhance the heritage and rural character of the North Shore of O‘ahu, Hawai‘i, in partnership with communities from Ka‘ena Point to Kahalu‘u. Direct Testimony of Gil Riviere.

3. Elizabeth Rago ("Rago") is an individual who resides in Kahuku near the proposed Na Pua Makani Wind Energy Project site.

B. Procedural History

a. Prior to Contested Case

4. Because the proposed Project will utilize State lands, a Final Environmental Impact Statement ("FEIS") was prepared and approved for the Project. Exs. A-12 through A-26.

5. The FEIS was accepted by the Board on July 22, 2016, and notice of the acceptance was published in the OEQC *Environmental Notice* on August 8, 2016. Ex. A-13; Ex. A-39 at 4; Ex. A-40 at 5-7. No timely legal challenge to the acceptance of the FEIS was filed pursuant to Hawai`i Revised Statutes ("HRS") § 343-7.

6. The public was notified of the proposed HCP through the notices published in OEQC's *Environmental Notice*. The draft HCP was published in the *Environmental Notice* on March 8, 2015. Ex. A-37; Ex. A-29 (Oller Written Direct Testimony ("WDT")) at ¶ 107. The initial 60-day public comment period was extended to 90-days in the May 8, 2015 *Environmental Notice*. Ex. A-38; Ex. A-29 (Oller WDT) at ¶ 108. The notice identified the area encompassed by the HCP, the proposed Project and HCP activities, and the ecosystems, natural communities, and habitat types within the HCP area. *See* Ex. A-37; Ex. A-29 (Oller WDT) at ¶ 108.

7. Both public input and relevant data were requested and received during this comment period. Ex. A-26 (Copies of HCP comments and data received during comment periods); Ex. A-29 (Oller WDT) at ¶ 109.

8. A public hearing on the draft HCP was held on June 4, 2015. Ex. A-29 (Oller WDT) at ¶ 109. Additionally, the Endangered Species Recovery Committee ("ESRC") noticed and held public meetings on the proposed final HCP, including the meeting on December 14, 2015 and the final public meeting on February 25, 2016. Vol. 1, Tr. 08/07/17 at 154:3-11.

9. Between the time of the public hearing on the draft HCP and the final HCP, Applicant increased the maximum height of the wind turbine generators ("WTGs") for the Project to a maximum of 200 meters. No public hearing was held to address the change in WTG height. Tr. 8/7/17 at 52:21 to 54:24 (Oller).

10. The HCP was developed through consultation not only with the ESRC, but also with DOFAW and the US Fish & Wildlife Service ("USFWS"), species experts, other important stakeholders, and the public. Input and the incorporation of requirements and revisions from the

ESRC occurred throughout the development process and public review periods of the HCP. Public meetings with the ESRC were held on the following dates:

- July 2, 2014 – Informational presentation to ESRC
- March 30, 2015 – ESRC site visit to the Project
- March 31, 2015 – Review of draft HCP during the State public comment period
- December 17, 2015 – Review of draft final HCP
- February 25, 2016 – Review of revised draft final HCP; ESRC recommendation to Board for approval of final HCP granted

Ex. A-29 (Oller WDT) at ¶ 113.

11. At its February 25, 2016 meeting, the ESRC agreed to recommend to the Board that the HCP be approved. Ex. A-2 at 4; Ex. A-36.

b. Contested Case Proceedings

12. The HCP and ITL were first brought before the Board for consideration on October 28, 2016. Decision-making was deferred at the time and the matter was again presented to the Board on November 10, 2016.

13. At the November 10, 2016 Board meeting, KNSC requested a contested case, as did Kent Fonoimoana. Consequently, the Board again deferred decision-making.

14. KNSC followed up its oral request for a contested case hearing with the required written petition on November 19, 2016.

15. On November 21, 2016, the Board received four additional written petitions for a contested case hearing—one from Rago, and three separate petitions from Kent Fonoimoana, one each on behalf of himself individually, as President of Kahuku Community Association ("KCA"), and as President of Makani Pono ‘O Kahuku ("MPK") (Fonoimoana, KCA and MPK are collectively referred to herein as the "Fonoimoana Petitioners").

16. Over the written objections from Applicant, the Board, on December 9, 2016, approved KNSC's petition for a contested case. The request for approval of the HCP and ITL was thus withdrawn pending the outcome of the contested case proceeding. Ex. A-41 at 15 (12/09/16 BLNR Minutes).

17. On January 13, 2017, the Board voted to consolidate the Rago, Fonoimoana, KCA, and MPK petitions for a contested case hearing with KNSC's contested case hearing and left the determination of standing of these petitioners to the hearing officer. Ex. A-42 at 9 (01/13/17 BLNR Minutes).

18. On February 14, 2017, the Board issued Minute Order No. 1 selecting Yvonne Y. Izu as the Hearing Officer in this proceeding, but allowed the parties and petitioners the opportunity to file objections. No objections were received.

19. On April 27, 2017, the Fonoimoana Petitioners, through counsel James Wright, Esq., formally withdrew their petitions for a contested case proceeding. Ex. A-43.

20. With no objections, Rago was granted standing to participate in the contested case proceeding pursuant to Hawai`i Administrative Rule § 13-1-31(c). Minute Order No. 4, as corrected by Errata to Minute Order No. 4.

21. The issues in the contested case proceeding were set forth in Minute Order No. 6 and Minute Order No. 7.

22. The Notice of Contested Case Hearing was issued on June 7, 2017.

23. Applicant filed its Opening Brief, written witness statements and exhibits on June 26, 2017. KNSC and Rago filed Responsive Briefs, written witness statements and exhibits on July 17, 2017. On July 25, 2017, Applicant filed its Reply Brief, written reply testimony and exhibits.

24. On July 13, 2017, KNSC submitted a request for subpoenas for Scott Fretz, Dr. Frank Bonaccorso, Marcos Gorreson, Corinna Pinzari, Andre Raine, and Jay Penniman. Applicant filed an objection to the request and the request was denied by the Hearing Officer. Minute Order No. 8. KNSC filed a motion for reconsideration, and amending its original request for subpoenas of six persons, and agreed to waive their request for the others, except one: Mr. Scott Fretz ("Fretz"). The motion for reconsideration was granted and a subpoena for the appearance of Fretz at the hearing was issued. Minute Order No. 9.

25. On August 7, 2017, immediately preceding the evidentiary hearing, arguments were heard from KNSC and the Applicant on KNSC's request that witnesses be excluded from the hearing room when not testifying. The Hearing Officer denied the request. Vol. 1, Tr. 08/07/17 at 7:3-8:16.

26. The evidentiary hearing was held on August 7 and 8, 2017.

27. All exhibits proffered by the parties were accepted into evidence.

28. Following the close of the evidentiary proceedings, the Hearing Officer set September 8, 2017 as the deadline for parties to submit proposed findings of fact, conclusions of law and decisions and orders. On August 23, 2017, KNSC filed a Motion for Extension of Deadline, requesting a three-week extension of the deadline to file its proposed findings of fact, conclusions of law and decision and order. The Motion for Extension was denied, but the deadline for submission of proposed findings of fact, conclusions of law, and decisions and orders was revised to September 11, 2017.

29. All parties timely filed their respective proposed findings of fact, conclusions of law, and decisions and orders.

C. Description of the Proposed Project

30. The Na Pua Makani Wind Energy Project ("Project") is a 25 megawatt wind generating facility sited on approximately 706.7 acres in Kahuku on the North Shore, Koʻolauloa District, Island of Oʻahu, identified by Tax Map Key Nos. (1) 5-6-008:006 and (1) 5-6-006:018 ("Project Site"). Ex. A-1 at 1, 4; *see also* Ex A-12 at 1-3.

31. Approximately 254.7 acres of the Project Site are State of Hawaiʻi lands managed by DLNR. The remaining lands that will be used for the Project (451.9 acres) are privately owned. Ex. A-1 at 4. No part of the proposed Project or the implementation of the HCP will require or involve the use of submerged lands, mining, or blasting. Ex. A-29 (Oller WDT) at ¶ 134; Ex. A-31 (Cutbirth WDT) at ¶ 24.

32. The Project proposes to develop 9 WTGs, a permanent meteorological tower ("Met Tower"), access roads, operation and maintenance facilities ("O&M"), electrical collection and interconnection infrastructure, including an electrical substation, a temporary laydown area, and associated infrastructure. Ex. A-1 at 4-5; Ex. A-31 at ¶ 8 (Cutbirth WDT).

33. The footprint for the permanent O&M building, storage, and parking area will be approximately one (1) acre. Ex. A-1 at 5; Ex. A-31 at ¶ 8 (Cutbirth WDT). Figure 2 of the HCP shows the proposed Project layout. Ex. A-1 at 3; Ex. A-31 at ¶ 8 (Cutbirth WDT).

34. The maximum blade tip height is anticipated to range from 427 feet (130 meters) to 656 feet (200 meters) above ground level. Ex. A-1 at 5; Ex. A-31 at ¶ 9 (Cutbirth WDT). At present, there are no commercially available turbines that are 656 feet (200 m). Vol. 1, Tr. 08/07/17 at 18:16-19. The Met Tower will be approximately 262 feet tall. Ex. A-1 at 6; Ex. A-31 at ¶ 10 (Cutbirth WDT).

35. The use of fewer, but taller WTGs was selected in response to state agency comments as well as community concerns about visual impacts. Vol. 1, Tr. 08/07/17 at 22:8-12.

A visual impact analysis of the wind turbines at 656 feet tall was done. Vol. 1, Tr. 08/07/17 at 22:18-20; Ex. A-12 § 4.16.

37. During construction, approximately four (4) acres (which includes the 1 acre permanent site) will be used for temporary storage and laydown area, refueling, and waste collection. Ex. A-1 at 5; Ex. A-31 at ¶ 10 (Cutbirth WDT). Staging areas disturbed during construction but not needed for permanent operations will be revegetated with non-invasive resident species compatible with Project operations. Ex. A-1 at 6; Ex. A-31 (Cutbirth WDT) at ¶ 10.

38. The anticipated life of the Project is 21 years (1 year for construction and 20 years of commercial operation). Ex. A-12 at 2-29; *see also* Ex. A-1 at 4; Ex. A-31 at ¶ 11 (Cutbirth WDT). After that time, Applicant will re-evaluate whether to continue operating the Project, or to decommission it. Ex. A-12 at 2-29; Ex. A-31 (Cutbirth WDT) at ¶ 11. If the Project operation is extended beyond the initial 21-year period, the facilities may be upgraded, with appropriate lease, modifications, permits, and approvals, as required. Ex. A-12 at 2-29.

39. If the Project is decommissioned, the power generation equipment and associated Project infrastructure will be removed and the site will be returned to a condition that is as close to its pre-construction state as practicable. Ex. A-1 at 4. The decommissioning process is anticipated to take approximately 1 year and will be done in accordance with the provisions of Applicant's lease with the DLNR, lease with private landowner, and the Power Purchase Agreement ("PPA") with Hawaiian Electric Company ("HECO"). *Id.*

40. The purpose of the proposed Project is to generate renewable wind energy on the island of O‘ahu. Ex. A-1 at 1; Ex. A-29 at ¶ 115 (Oller WDT). This Project will help Hawai‘i achieve its 100% renewable energy initiative that was signed into law by the Governor last

summer. H.B. 623; HRS § 269-92; Ex. A-29 at ¶ 115 (Oller WDT). To that end, wind-generated energy facilities are authorized under the State land use laws. *See* HRS § 205-2; Ex. A-29 (Oller WDT) at ¶ 116. Furthermore, renewable energy facilities, like the proposed Project, are encouraged by the State of Hawai‘i, through the Hawai‘i Clean Energy Initiative. Ex. A-29 (Oller WDT) at ¶ 117.

D. Need for ITL and HCP

41. The “take” of any endangered or threatened species is prohibited. HRS § 195D-4(e). However the Board may issue an Incidental Take License (ITL) to permit take otherwise prohibited, if the take is incidental to, and not for the purpose of, carrying out an otherwise lawful activity. HRS § 195D-4(g). Issuance of the ITL is conditioned upon the preparation, and implementation, of a Habitat Conservation Plan (HCP). HRS § 195D-4(g).

42. The Project has the potential to result in incidental take of species listed under the Federal Endangered Species Act (ESA) and state endangered species statutes (HRS Chapter 195D). The following listed species have the potential to be killed or injured by colliding with Project WTGs or other components, or during Project activities:

Scientific Name	**Hawaiian Name**	**Common Name**
Puffinus newelli	\`A\`o	Newell’s shearwater
Himantopus mexicanus knudseni	Ae\`o	Hawaiian black-necked stilt
Fulica alai	\`Alae ke\`oke\`o	Hawaiian coot
Gallinula chloropus sandvicensis	\`Alae \`ula	Hawaiian common moorhen
Anas wyvilliana	Koloa maoli	Hawaiian duck
Branta sandvicensis	Nene	Hawaiian goose
Asio fammeus sandwichensis	Pueo	Hawaiian short-eared owl
Lasiurus cinereus semotus	Ope\`ape\`a	Hawaiian hoary bat

Indirect take of some of these species could also occur, as it is possible that the death of a listed adult during the breeding season could result in the loss of eggs or dependent young. Ex. A-1 at 1.

43. Applicant's study of the Project Area to prepare the HCP included a biological reconnaissance survey and a 1-year avian point count survey. *See* Exs. A-3 & A-4; Ex. A-29 (Oller WDT) at ¶ 98. These surveys were one of the primary sources in understanding the distribution and abundance of any species in the Project Area. *Id.* Results from these surveys are described in Section 3 of the HCP. Ex. A-1 at 13-37; Ex. A-29 (Oller WDT) at ¶ 99. Overall, the proposed Project Area has been highly disturbed by agricultural activities, and the vegetation is dominated by a mixture of aggressive non-native weedy species that took over following the abandonment of sugar cane agriculture. See Ex. A-18 (App. E to FEIS – Biological Survey Report) at 2; Ex. A-29 (Oller WDT) at ¶ 99. Plants and wildlife are dominated by non-native species and no listed threatened or endangered plant species were identified in the Project Area. Ex. A-1 at 4; Ex. A-29 (Oller WDT) at ¶ 100. Non-listed native species are widespread and common outside of the Project Area. Local impacts to these species associated with the construction, operation and decommissioning of the Project will not substantially increase the risk of causing any of those species to become threatened or endangered. Ex. A-1 at 4; Ex. A-29 (Oller WDT) at ¶ 101.

E. HCP Provisions By Species

44. The criteria for an HCP are set forth in HRS § 195D-21 and HRS § 195D-4(g). Because the minimization and mitigation measures vary among the Covered Species, the following findings of fact are structured in a manner that discusses the HCP provisions with respect to each species separately, except that the Waterbirds - Ae`o (Hawaiian black-necked

stilt), `Alae ke`oke`o (Hawaiian coot), `Alae `ula (Hawaiian common moorhen), and Koloa maoli (Hawaiian duck) - are grouped together.

a. <u>`A`o</u>

45. The `a`o (Newell's shearwater) is a migratory, highly pelagic seabird endemic to the Hawaiian Islands and is listed as threatened under the ESA and by the State. Like other procellariids (i.e., shearwaters, petrels, fulmars, and prions), the `a`o spends up to 80% of its life at sea, only returning to land to breed. Ex. A-1 at 19-20.

46. The Newell's Shearwater Recovery Plan, completed in 1983, and the State of Hawai`i Comprehensive Wildlife Conservation Strategy recommend several strategies to benefit `a`o. The first strategy is recommending efforts to reduce fallout. Seabird fallout occurs when birds are attracted to artificial lights causing disorientation, thus resulting in birds coming to the ground as a result of collision or exhaustion. Other recommended measures include the protection of known colonies, the development of efficient predator control methods, and the expansion of our knowledge of the species' status and distribution. Ex. A-1 at 20.

47. Important factors in the decline of `a`o include the loss of breeding habitat, predation by introduced mammalian predators, and historical hunting by humans. Other threats include collisions with power lines and other human-made structures, disorientation and fall out associated with light attraction, impacts to pelagic habitat associated with climate change, and decline in food resources due to overfishing. Ex.A-1 at 21.

48. The Project area, consisting of low elevation habitat dominated by aggressive introduced species, is not appropriate `a`o nesting habitat. However, `a`o could fly through the Project area when moving between potential unknown nesting colonies in the Ko`olau or Waianae mountain ranges and the ocean. Ex. A-1 at 22.

49. Applicant requests an authorized take of 4 adults/fledged young (direct take) and 2 chicks/eggs (indirect take) of `a`o for the 21-year permit term. Ex. A-1 at 48.

50. Direct take is conservatively estimated based on observed passage rates and flight heights of `a`o -like targets observed over 3 seasons of avian radar surveys, the physical attributes of the WTGs, and an estimate of the species' ability to avoid collision. Ex. A-1 at 45.

51. The potential for indirect take of `a`o exists if birds transit the site while flying to or from an undiscovered nesting colony, i.e., if an adult is killed while incubating an egg or rearing a chick. Ex. A-1 at 47.

52. Should the maximum requested take of 4 adult/fledgling `a`o occur, it should not have a population-level impact, as it would represent an increase in mortality rate of 0.01 percent of the population distributed over the 21-year permit term. Ex. A-1 at 48.

53. **Avoidance and Minimization**: The HCP provides for the following measures to minimize take of Newell's shearwaters:

- The three Project temporary guyed met towers were fitted with bird flight diverters and/or white poly tape to increase visibility and, as a result, the likelihood of avoidance by `a`o.

- The Project plans to install an un-guyed, free-standing permanent met tower to maximize the detectability of all features of the structure for birds and bats and minimize the risk of collisions. This permanent tower would replace one temporary guyed met tower and the remaining temporary met towers would be removed before the commercial operation date.

- On-site lighting at the O&M building and substation will be shielded and/or directed downward, triggered by a motion detector, and fitted with non-white light bulbs. Lighting is only expected to be used when workers are at the site at night. Most operations and maintenance activities are expected to occur during daylight hours.

- Nacelle lighting will not be used expect as required by FAA standards. Flashing red lights have been shown to not be attractive to birds and will be used in accordance with FAA requirements.

- The collection line will be placed below ground to the maximum extent practicable, thereby reducing the risk of collision of `a`o.

- New above-ground portions of power lines associated with the Project will use line marking devices to improve visibility to birds and follow Avian Protection Plan Guidelines.

- NPM will implement low wind speed curtailment from March – November between sunset and sunrise. Although this minimization measure is proposed to reduce the potential impacts to `ope`ape`a, it will also reduce the risk to `a`o, which could transit the Project at night from April – November.

- NPM will maximize the amount of construction activity that can occur in daylight during the seabird breeding season including the peak fledgling period (approximately October 15 to November 23).

- Should nighttime construction be required, NPM will use shielded lights and maximize the use of non-white lights, provided that construction safety is not compromised, to minimize the attractiveness of construction lights to wildlife. A biological monitor will be in the construction area to watch for the presence of Covered Species at all times during nighttime construction. Should a Covered Species be observed, construction activities will stop and construction lighting will be shut down until the individual(s) move out of the area.

- When not in use, construction cranes will be lowered at night, when practicable, to minimize the risk of bird collisions.

Ex. A-1 at 38-40.

54. **Mitigation**. The USFWS Newell's Shearwater Recovery Plan and the State of Hawai`i's Comprehensive Wildlife Conservation Strategy for `a`o recommend efforts to reduce fallout, protect known colonies, and develop efficient predator control methods while expanding knowledge of the species' status and distribution. Although providing mitigation for `a`o on Oahu would be preferred, this approach is not likely the most effective because no nesting colonies are known on Oahu and locating any breeding populations, if any exist, would take considerable effort with low chance of success. Combined with additional threats such as fallout potential due to heavy urbanization on Oahu, this makes conservation efforts on Oahu impractical on a scale that is within the scope of the Project. Ex. A-1 at 66.

55. USFWS has created an account with the National Fish and Wildlife Foundation (NFWF) where funds for `a`o mitigation can be deposited and then used according to an appropriate `a`o conservation plan. The overall intent is that pooled resources can be used to fund larger management projects or to resolve larger research questions targeted at the recovery of `a`o that could have been supported through smaller scale investments. Ex. A-1 at 67.

56. NPM will make a one-time payment of $160,800, payable no later than the commercial operation date ("COD") to NFWF to be used for an appropriate `a`o conservation plan. Ex. A-1 at 67-68 and Appendix F. Within one year of the COD, USFWS will have developed an appropriate `a`o conservation plan to which NPM's payment will have contributed. The conservation plan will include appropriate biological measures of success. Ex. A-1 at 67-68.

57. **Measures of Success**. The mitigation measure for `a`o for the Project will have been accomplished upon the payment of $160,800 to NFWF by the commercial operation date. Ex. A-1 at 68.

58. NPM will provide the status and results of the research or management efforts in its annual report to the agencies. Results will include biological measures related to reductions in predators or other measures appropriate to the program that is funded, with results appropriately scaled to the relative proportion of the overall funds that were contributed by NPM. Ex. A-1 at 68. However, it is not anticipated that NPM will have to provide different or additional mitigation even if biological measurements of success are not met.

b. Hawaiian Waterbirds

59. Four waterbirds – koloa maoli (Hawaiian duck), ae`o (Hawaiian black-necked stilt), `alae ke`oke`o (Hawaiian coot), and `alae `ula (Hawaiian common moorhen) – occur or have the potential to occur in the Project area. Aside from the threat of hybridization with feral

mallards for the koloa maoli, all of these waterbirds face the same suite of threats. The Revised Hawaiian Waterbirds Recovery Plan, completed in 2011, and the State of Hawai`i`s Comprehensive Wildlife Conservation Strategy recommend preservation of wetland habitat and management of introduced predators in priority wetlands. Ex. A-1 at 26.

60. **Koloa maoli** (Hawaiian Duck). The endangered koloa maoli is a small dabbling duck that is endemic to the Hawaiian Islands. Koloa maoli utilize a variety of wetland habitats, from sea level up to 10,000 feet in elevation, including freshwater marshes, flooded grasslands, coastal ponds, streams, montane pools, forest swamplands, agricultural and artificial wetlands, and irrigation ditches. Ephemeral wetlands are important foraging habitat for koloa maoli. Ex. A-1 at 26.

61. Koloa maoli breed year-round, although the majority of nesting records are from March through June. Nesting occurs on the ground near, but not necessarily adjacent to, water, but little else is known of specific koloa maoli nesting habits. Ex. A-1 at 26.

62. Koloa maoli are non-migratory but exhibit some seasonal, altitudinal, and inter-island movements. However, the timing and mechanics of these movements are not well understood. The species may use different habitats for nesting, feeding, and resting, and may move seasonally among areas. A seasonal pattern of high use of lowlands in winter and declining use in the summer may reflect dispersal into montane areas during breeding season. Ex. A-1 at 27.

63. Koloa maoli historically occurred on all the main Hawaiian Islands except Lana`i and Kahoolawe; however, by the 1960s, they were found in small numbers only on Kauai and probably Niihau. From the late 1950s through the early 1990s, koloa maoli were reintroduced to Oahu, Maui, and Hawai`i Island through captive propagation and release. Populations of koloa

maoli currently exist on Kauai, Niihau, Maui and Hawai`i Island; however, genetics studies show that the Oahu population is heavily compromised through hybridization with feral mallards. Ex. A-1 at 27.

64. The koloa maoli population appears to be increasing overall due to increases in the population on Kauai; however, pure koloa maoli populations are declining on other islands. These population trends may be inaccurate due to incomplete survey coverage and difficulty in distinguishing koloa maoli from hybrids. Ex. A-1 at 27.

65. The only mechanism for the development of pure koloa maoli on Oahu would be an intensive koloa maoli reintroduction and feral mallard management effort conducted by USFWS or DOFAW. The Recovery Plan for Hawaiian Waterbirds identifies the removal of feral mallards on all islands as a critical element in the recovery of the species. Although the Recovery Plan prioritizes the establishment of self-sustaining populations of koloa maoli on Maui and/or Molokai, DOFAW has initiated planning of recovery efforts that are to include populations on Oahu. Ex. A-1 at 28-7-28.

66. During biannual winter counts from 1999-2003, koloa maoli-like birds (presumed hybrids) were reported in low numbers at the following wetlands within 5 miles of the Project: James Campbell National Wildlife Refuge ("JCNWR") (core wetland), Kahuku aquaculture ponds (supporting wetland), La`ie wetlands (supporting wetland), the Kuilima Wastewater Treatment Plant at Turtle Bay (supporting wetland), and the Turtle Bay Golf Course Ponds. "Core wetlands" are areas that provide habitat essential for survival and recovery, supporting large populations of Hawaiian waterbirds; "supporting wetlands" are areas that provide habitat important for survival and recovery, but may support only smaller waterbird populations or may

be occupied only seasonally. These areas represent potential areas of future koloa maoli occupancy. Ex. A-1 at 28.

67. Assuming a reintroduction effort is successful, suitable habitat for koloa maoli in the Project area is very limited. A small stretch of Malaekahana Stream along the southern border of the Project area could be suitable habitat for koloa maoli; however the abundance of high quality habitat at managed wetland areas outside of the Project area minimizes the importance of this area. Therefore, if koloa maoli occur in the Project area, this occurrence would be primarily limited to their transit of the area when flying between wetland habitats outside of the Project area. Ex. A-1 at 28.

68. No koloa maoli-like birds were observed in the Project area during avian point count surveys conducted over a 1-year period. In contrast, surveyors recorded 61 koloa maoli-mallard hybrids in adjacent wetland areas, indicating the suitability of habitat for koloa maoli in the vicinity of the Project. Ex. A-1 at 28.

69. **Ae`o** (Hawaiian black-necked stilt). The endangered ae`o is an endemic subspecies of the black-necked stilt, a moderately sized wading bird. Ae`o are associated with a variety of aquatic habitats, primarily within the lower elevation coastal plains of Hawai`i, but are limited to habitats with a water depth of less than 9 inches, and sparse low-growing vegetation or exposed tidal mudflats. Ex. A-1 at 28.

70. Nesting generally occurs from mid-February through August on freshly exposed mudflats interspersed with low-growing vegetation. Ex. A-1 at 28.

71. Ae`o are opportunistic feeders, eating a wide variety of invertebrates and other aquatic organisms that occur in shallow water and mudflats. Ae`o typically feed in shallow

flooded wetlands that are ephemeral in nature, and have been documented moving between islands in order to exploit seasonal food resources. Ex. A-1 at 29.

72. Ae`o are found on all the main Hawaiian Islands except Kahoolowe and is non-migratory except for seasonal movements between adjacent islands. Long-term census data show year-to-year variability in the number of ae`o observed, but indicate statewide populations have been relatively stable or slightly increasing through the late 1980s. Biannual waterbird surveys from 1998 through 2007 documented an average population of 1,484 birds, ranging from approximately 1,100 to 2,100 birds. The annual variability is at least partially a result of rainfall patterns and reproductive success. Ex. A-1 at 29.

73. Available habitat is thought to limit the carrying capacity for ae`o. Models indicate that if the currently available habitat is maintained, primarily through predator control and regulation of water level fluctuations, the ae`o population should increase to fill available habitat. Conversely, altering the model parameters to reflect a cessation of predator control resulted in 100 percent chance of extinction over 200 years, with a mean time to extinction of 32 years. Ex. A-1 at 29.

74. Oahu supports the largest number of ae`o in the Hawaiian Islands, accounting for 35 to 50 percent of the state's population (450 to 700 birds during any single year). On Oahu, ae`o can be found in large concentrations at JCNWR, the Kahuku aquaculture ponds, and the Pearl Harbor National Wildlife Refuge. Both JCNWR and the Kahuku aquaculture ponds are within 5 miles of the Project area, and are core and supporting wetlands, respectively. Other wetlands within 5 miles of the Project area where ae`o have been observed include the Kahuku airstrip ponds, Coconut Grove Marsh, the Turtle Bay Golf Course ponds, and the Kuilima Wastewater Treatment Plant at Turtle Bay. Ex.A-1 at 29.

75. There is no suitable habitat for ae`o in the Project area. Ae`o require wetlands, marshes, or ponds, and these are not present in the Project area. Therefore, if ae`o occur in the Project area, this occurrence would be primarily limited to their transit of the area when flying between wetland habitats outside of the Project area. Ex. A-1 at 29-30.

76. No ae`o were observed within the Project area during Project avian point count surveys conducted over a 1-year period. In contrast, surveyors recorded 40 ae`o detections in wetland areas adjacent to the Project and studies indicated some movement between JCNWR and wetlands outside of the refuge and the adjacent shrimp ponds. Based on the known biology of the species, the frequency of ae`o transiting the Project area is likely to be low. Ex.A-1 at 30.

77. **`Alae ke`oke`o** (Hawaiian coot). The endangered `alae ke`oke`o is a non-migratory species endemic to the Hawaiian Islands. Previously considered a subspecies of the American coot (*Fulcia americana*), and originally listed under the ESA as such, the `alae ke`oke`o is now regarded as a distinct species. Ex.A-1 at 30.

78. `Alae ke`oke`o are associated with lowland wetland habitats that have emergent vegetation interspersed with open water. They typically occur along the coastal plain from sea level up to 850 feet elevation. `Alae ke`oke`o are generalist feeders, consuming seeds and leaves of aquatic plants, snails, crustaceans, and aquatic or terrestrial insects, tadpoles, and small fishes. They forage in mud, sand, or near the surface of the water, and they can dive up to 48 inches below the water surface. Ex. A-1 at 30.

79. `Alae ke`oke`o nest on open freshwater and brackish ponds, flooded taro fields, shallow reservoirs and irrigation ditches. They construct floating or semi-floating nests of aquatic vegetation so that nests can move with changing water levels. They are thought to breed

opportunistically in response to rainfall, but peak breeding occurs March – September. Ex. A-1 at 30.

80. `Alae ke`oke`o are non-migratory, but exhibit pronounced irregular movements based on rainfall. They commonly wander, and larger bodies of water may have large concentrations of birds during the non-breeding season. As movements are associated with fall and winter rain events, which occur after the peak breeding season, movements between wetlands are most likely to occur after independence of young. Ex. A-1 at 30-31.

81. `Alae ke`oke`o historically occurred on all the main Hawaiian Islands except Lana`i and Kahoolawe, which lacked suitable wetland habitat. However, they are now present on Lana`i due to the creation of artificial wetland-like features, such as water treatment sites. `Alae ke`oke`o have always occurred in greatest numbers on Oahu, Maui and Kauai, and were likely once fairly common in large natural marshes and ponds. Ex. A-1 at 31.

82. Winter biannual waterbird surveys from 1997 through 2006 indicated a population average of approximately 2000 `alae ke`oke`o, ranging from approximately 1,500 to 2,800 birds statewide. Waterbird counts indicate short-term population fluctuations and a slight long-term increase in population between 1976 and 2008. As `alae ke`oke`o disperse readily and exploit seasonally flooded wetlands, their populations naturally fluctuate according to climatic and hydrologic conditions. Ex. A-1 at 31.

83. During 1995 – 2007, the `alae ke`oke`o populations on Oahu fluctuated between approximately 500 and 1,000 birds. Large concentrations have been observed at JCNWR, the Kahuku aquaculture ponds, the Kuilima wastewater treatment plant, the Ka`elepulu Pond in Kailua, the Pearl Harbor NWR, and the Hawai`i Prince Golf Course, the first three of which are within 5 miles of the Project area. Other wetlands within 5 miles of the Project where `alae

ke`oke`o have been observed in smaller numbers include Coconut Grove Marsh, La`ie wetlands, and the Turtle Bay golf course ponds. Ex.A-1 at 31.

84. There is no suitable habitat for `alae ke`oke`o in the Project area. In lowland environments, `alae ke`oke`o use wetlands, marshes, or ponds, which are not present in the Project area. Therefore, if `alae ke`oke`o occur in the Project area, occurrences would be primarily limited to their transit of the area when flying between wetland habitats outside of the Project area. Ex. A-1 at 31.

85. No `alae ke`oke`o were observed within the Project area during avian point count surveys conducted over a 1-year period. In contrast, surveyors detected 14 individuals in wetland areas adjacent to the Project. Based on the know biology of the species and the results of avian point counts, the frequency of `alae ke`oke`o transiting the Project area is likely to be low. Ex. A-1 at 31.

86. **`Alae `ula** (Hawaiian common moorhen). The endangered `alae `ula is a non-migratory subspecies endemic to the Hawaiian Islands. It is predominantly associated with lowland wetland habitats that have emergent vegetation interspersed with open water including natural ponds, marshes, streams, springs or seeps, lagoons, grazed wet meadows, taro and lotus fields, shrimp aquaculture ponds, reservoirs, sedimentation basins, sewage ponds, and drainage ditches. They appear to have a preference for freshwater over brackish. Ex. A-1 at 32.

87. `Alae `ula are apparently opportunistic feeders; the diet likely varies by habitat and includes, algae, aquatic insects, mollusks, snails, seeds and other plant parts. `Alae `ula glean food from the water surface and leaves of floating plants while swimming or walking on these plants. Although `alae `ula typically forages in and along areas of dense vegetation, they also forage on open ground. Ex. A-1 at 32.

88. `Alae `ula typically nest over shallow water (less than 24 inches) along emergent vegetation edges of narrow interconnecting waterways, but also in wet meadows or on solid ground in the presence of tall cover. They nest year-round, but breeding activity is concentrated during March – August and is affected by both vegetation height and water levels. Ex. A-1 at 32.

89. `Alae `ula are non-migratory and generally sedentary; however, they readily disperse in spring, presumably to breed. As with other Hawaiian waterbirds, dispersal may be related to the timing of wet and dry periods with dispersal occurring with the creation of new seasonal habitat during periods of flooding. Ex. A-1 at 33.

90. Given the short duration of dependence, sedentary nature of the species, and timing of dispersal events, `alae `ula are unlikely to move between wetland areas when caring for dependent young. Ex. A-1 at 33.

91. `Alae `ula historically occurred on all of the main Hawaiian Islands except Lana`i (probably due to a lack of wetland habitat) and probably Niihau. From the late 19$^{th}$ to the mid-20$^{th}$ centuries, `alae `ula populations on all but Kauai and Oahu were extirpated. Reintroduction efforts on Maui, Molokai and Hawai`i Island all failed (although there are unsubstantiated reports of `alae `ula on Hawai`i Island and Maui from the late 20th century). Ex. A-1 at 33.

92. Although only a rough measurement of recent population trends exist, statewide population counts have been stable during the decade from 1997-2008, with an average count of 287 birds. Ex. A-1 at 33.

93. Approximately half the statewide population of `alae `ula resides on Oahu. Areas supporting the largest populations include Dillingham Ranch large pond, Amorient Aquafarm (part of Kahuku Aquaculture Farms, JCNWR Ki`i Unit, and Waimea Valley. Amorient

Aquafarm and JCNWR are within 5 miles of the Project. Other wetlands within 5 miles of the Project where `alae `ula have been observed in smaller numbers include Coconut Grove Marsh, La`ie wetlands, Kahuku Prawn Farms (part of Kahuku Aquaculture Farms), Punaho`olapa Marsh, and the Turtle Bay golf course ponds. Ex. A-1 at 33.

94. There is no suitable habitat for `alae `ula in the Project area. `Alae `ula use wetlands, marshes or ponds, which are not present in the Project area. Thus, if `alae `ula occur in the Project area, the occurrences would be primarily limited to their transit of the area when flying between wetland habitats outside of the Project area. Ex. A-1 at 33.

95. No `alae `ula were observed within the Project area during Project avian point count surveys conducted over a 1-year period. In contrast, surveys detected 16 individuals in wetland areas adjacent to the Project. Based on known biology of the species and the results of avian point counts, the frequency of `alae `ula transiting the Project area is likely to be low. Ex. A-1 at 33.

96. **Avoidance and Minimization**. Direct take of koloa maoli, ae`o, `alae ke`oke`o, and `alae `ula is anticipated to be low because of the lack of habitat, absence of these birds observed during the surveys, and the ability of the taxa to avoid collisions. Moreover, direct take of koloa maoli is expected to be low because many of the koloa maoli-like ducks on Oahu have been shown to be hybrids. Ex. A-1 at 51.

97. Overall, waterbirds are expected to have a low frequency of transiting the Project area because of their limited presence in the Project area and demonstrated avoidance behavior. None of these waterbird species have been detected as fatalities at existing wind generation facilities in the Hawaiian Islands. Ex. A-1 at 52.

98. Due to the low expected frequency of waterbirds transiting the Project area and the ability of waterbirds to detect and avoid obstacles, the risk of collision with other Project components is considered negligible. Project components such as construction equipment, and the met tower are stationary or slow moving and are more visible and affect a much smaller portion of the airspace than WTGs. In addition Project transmission lines will be marked increase visibility, which will make any risk of collision with the Project components negligible. Ex. A-1 at 52.

99. Because there is no waterbird habitat in the Project area, the potential for vehicles to kill waterbirds at the Project is negligible. Ex. A-1 at 52.

100. Applicant requests an authorize take of 4 koloa maoli, 4 ae`o, 8 `alae ke`oke`o and 8 `alae `ula over the 21-year permit term. Ex. A-1 at 52-53.

101. Direct take for these waterbird species could occur as a result of collision with the WTGs. Ex. A-1 at 52.

102. Although the direct take over the 21-year permit term is not anticipated to exceed 1 individual of each of the four Hawaiian waterbird covered species, the value is increased to account for uncertainty that is inherent when estimating the frequency and magnitude of a rare event over an extended period of time. Furthermore, as the estimated benefit of the proposed mitigation for the `alae ke`oke`o and `alae `ula is substantially higher than for the koloa maoli and ae`o, the estimated take for `alae ke`oke`o and `alae `ula is increased to reflect this difference. Ex. A-1 at 52.

103. Indirect take could occur if adults with eggs or dependent young occur as a fatality due to the Project. Such indirect take is unlikely as Hawaiian waterbirds are likely to

move among wetlands only after their young are independent. Thus, the potential for indirect take is considered negligible. Ex. A-1 at 52.

104. Should the requested take of the four waterbird species occur over the 21-year permit term, it should not have a population-level impact on the respective populations. Each of these species has a statewide population that is stable or increasing. Therefore, no population is likely to be particularly sensitive to losses on the order of one bird every 3 to 5 years. Ex. A-1 at 53.

105. **Mitigation**. NPM will contribute $126,250 for the design and construction of a 1,555-ft stretch of fence that would create a boundary between Hamakua Marsh and the adjacent shopping center. The fence will include informational signs to educate the public about resident waterbirds and actions that can be taken to support them. Fence construction will be completed within one year of the COD. Additionally, NPM will contribute funds towards the maintenance of the fence for 2 years from the completion of fence construction. Ex. A-1 at 73, Appendix F.

106. In addition to fence construction and maintenance, NPM will provide funds for a half-time staff biologist who will act as an on-site monitor and conduct public outreach and education. Funding for this half-time staff biologist will commence upon completion of construction of the fence and continue for 2 years thereafter. Funding for fence maintenance and the half-time biologist amounts for $43,000 per year for two years. Ex. A-1 at 73, Appendix F.

107. The USFWS Recovery Plan for Hawaiian Waterbirds identifies habitat loss and degradation and predation by introduced mammals as the primary threats to ae`o, `alae ke`oke`o and `alae `ula, and identifies these factors as the most important causes of decline in koloa maoli. Appropriate habitat management of core wetlands is the first recovery criterion listed for each of these waterbirds. Ex. A-1 at 70-71.

108. Hamakua Marsh is a state-owned (DLNR) waterbird sanctuary located on the edge of Kailua town and is adjacent to Kawainui Marsh, a waterbird management area. Hamakua Marsh is managed as breeding habitat for ae`o, `alae ke`oke`o and `alae `ula, and is likely to provide future habitat for koloa maoli should a population become established on Oahu through recovery efforts. Hamakua Marsh is identified as a core wetland in the USFWS Recovery Plan for Hawaiian Waterbirds. Ex. A-1 at 71.

109. Hamakua Marsh has an unprotected perimeter of high human traffic, which has resulted in a number of negative impacts including death and disturbance of waterbirds and an accumulation of trash at the site. A portion of the north boundary of the Hamakua Marsh abuts a shopping center, where local residents and nearby restaurants often discard bread or other food in the parking area. Attracted by the food, waterbirds leave the marsh and forage for crumbs in the parking area and these birds are regularly killed by vehicles and occasionally, by people. Additionally, dog owners throw tennis balls into the marsh for their dogs to retrieve, which disturbs nesting birds or can result in direct predation. Moreover, open access to the wetland invites trespassing and illegal disposal of garbage, degrading nesting habitat. Ex. A-1 at 71.

110. Controlling access to Hamakua Marsh and educating the public about threats to Hawaiian waterbirds should provide a net benefit to endangered waterbirds by reducing activities that have resulted in waterbird mortality. Ex. A-1 at 74.

111. **Measures of Success**. The HCP identifies the timely fence construction and funding for fence maintenance and a half-time staff biologist as the measures for successful mitigation. Ex. A-1 at 75.

112. Whether the fence is effective in reducing predation or improving breeding habitat is not included as a measure of success. Whether the staff biologist is effective in

educating the public or whether monitoring activities have a positive impact on improving habitat for waterbirds is not included as a measure of success. Ex. A-1 at 75.

c. Nene

113. The nene is the only remaining endemic goose in the Hawaiian Islands. It is listed as endangered under the ESA and by the State. Ex. A-1 at 24.

114. The draft Hawaiian Goose Recovery Plan, revised in 2004, and the State of Hawai`i Comprehensive Wildlife Conservation Strategy share several recommended strategies to benefit the Hawaiian goose. These include identifying and protecting nene habitat, restoring and enhancing habitat, controlling alien predators, and minimizing nene conflicts with human activities. Ex. A-1 at 24.

115. Nene typically remain on the islands on which they were hatched, but may range over large intra-island areas following the fledgling of young. The sedentary nature of the species suggests low levels of natural inter-island movement. A recent effort to translocate nene from Kauai to Hawai`i and Maui, however, has resulted in the unexpected occurrence of birds on Oahu. Two translocated adult geese and three goslings were documented at JCNWR, which is less than a mile from the Project area. Ex. A-1 at 25, 48.

116. Predation by non-native mammals is the greatest factor limiting nene populations. Feral cats, dogs, rats, and mongoose are each likely to be predators on Oahu, where the few birds present are close to human populations. Other threats to the species include lack of access to seasonally important lowland habitats, insufficient nutritional resources for breeding females and for goslings, human-caused disturbance and mortality (e.g., road mortality), behavioral problems related to captive propagation and inbreeding depression. Ex. A-1 at 25.

117. Habitats on Oahu that are most likely to support nene are lowland areas managed as golf courses, habitat for Hawaiian waterbirds, and grazed agricultural areas. In addition, areas where vegetation is mowed can be attractive to nene, which could include areas beneath WTGs. Ex. A-1 at 25-26.

118. Given the proximity of the Project to recently occupied habitat (JCNWR), it is possible that nene will use the Project area to forage during the permit term. In addition, nene has the potential to fly through the Project area in transit between foraging areas. Ex. A-1 at 26.

119. Applicant requests an authorized direct and indirect take of 6 adults/fledged young nene for the 21-year permit term. Ex. A-1 at 51.

120. Take is conservatively estimated based on as-yet unproven assumptions that the population of nene on Oahu would grow through future reproduction and arrival of additional birds. The HCP assumes that the nene population would increase from the current 3 to 50 individuals over the 21-year permit term and that the number of fatalities would increase as the population increases. Ex. A-1 at 48-51.

121. During the first 9.33 years of operation at the 20-WTG Kaheawa Pastures I Wind Project on Maui, 21 nene fatalities were found or 0.11 fatalities/WTG/year. A flock of more than 100 nene is currently resident in the vicinity of the Kaheawa Pastures I Wind Project. The take request for the Project used the take data from Kaheawa Pastures I Wind Project and adjusted for the facts and circumstances of the Project. Ex. A-1 at 49-51.

122. Should the maximum requested take of 6 nene occur, it should not have a population level impact, as it would represent an increase in mortality rate of less than 0.3 percent of the population distributed over the 21-year permit term. Ex. A-1 at 51.

123. **Avoidance and Minimization**. The HCP provides for the following measures to minimize take of the nene:

> Measures will be taken to increase visibility of met towers and decrease night time lighting.
>
> - A vehicular daytime speed limit of 25 miles per hour and a nighttime speed limit of 10 mph will be observed on the Project area roads to minimize the potential for vehicle collision with nene.
> - Should nene begin to use the Project area for foraging or nesting, NPM will reduce vehicular daytime speed limit to 10 mph.
> - To the extent practicable, NPM will minimize the creation of suitable nene nesting habitat (shrubs adjacent to low-growing grass) in developing post-construction monitoring search plots.
> - Trash will be collected in lidded receptacles and removed from the construction area on a weekly basis to avoid attraction of ants and other animals such as mongooses, cats, and rats that may negatively affect the nene or NPM's ability to detect fatalities of nene.

Ex. A-1 at 38-40.

124. **Mitigation**. Within six months of the COD, NPM will contribute $50,000 for fence construction at the JCNWR. If, prior to construction of the fence, USFWS and DOFAW determine that another mitigation approach would have greater benefit to the nene population on Oahu, the same level of funding could be used toward an alternative mitigation approach. Such an approach would most likely consist of funding of predator control efforts in an area of nene use. Ex. A-1 at 68, Appendix F.

125. Given the small size of the nene population on Oahu, USFWS and DOFAW have proposed a mitigation approach consisting of habitat management to reduce potential impacts of predation in suitable habitat. Ex. A-1 at 68.

126. The JCNWR contains suitable nene nesting habitat and is in proximity to the area where the adult pair of nene nested in the winter of 2013/2014. The area remains of frequent use

for the Oahu resident nene and is expected to be used by nene into the future. Fence construction is expected to benefit the nene population because 1) the species exhibits strong site fidelity and natal philopatry, 2) the population is assumed to grow over time at least partially due to natural reproduction, and 3) USFWS is committed to providing long-term fence maintenance and management of the area. The proposed hogwire fence will significantly reduce the predation from dogs, which have been identified as a predator of concern for the nene at this site, and, thus will increase the productivity and survival of the nene. Ex. A-1 at 68.

127. **Measures of Success**. The mitigation measure for nene for the Project will have been accomplished upon payment of $50,000 to USFWS within six months of the COD. Ex. A-1 at 70, Appendix F.

128. NPM will provide status/results of the construction of the fence in its annual report to the agencies. Results reported will include documentation of observed nene and activities within the fenced area, documentation of pig and/or dog activity within the fenced area, and documentation of other management efforts that are facilitated by the presence of the fence. Ex. A-1 at 70.

129. If an alternative mitigation approach (other than fencing of a portion of the JCNWR) is used, the biological measures will be reported that will satisfy the net benefit requirement. Ex. A-1 at 70.

d. <u>Pueo</u>

130. The pueo (Hawaiian short-eared owl) is an endemic subspecies of the short-eared owl. It likely colonized the islands following the arrival of the Polynesians to the island chain and the concurrent introduction of the Polynesian rat. The Oahu population of pueo is listed as endangered by the State. Ex. A-1 at 35.

131. The State of Hawai`i's Comprehensive Wildlife Conservation Strategy recommends a combination of conservation actions, monitoring and research. These recommendations include continuing conservation efforts at refuges and wildlife sanctuaries, expanding survey efforts to monitor populations status and trends on Oahu, and conducting research into limiting factors such as "sick owl syndrome" and vehicle collisions. Ex. A-1 at 35.

132. Pueo are most common in open habitats, including grasslands, shrublands, and montane parklands; however, they use a broad spectrum of other habitats including wetlands, wet and dry forests, and urban areas. Pueo have been found from sea level to 8,000 feet above mean sea level. Unlike its mainland counterpart, pueo is largely diurnal. Ex. A-1 at 35.

133. Little is known about the breeding biology of pueo, but active nests have been found year round. Ex. A-1 at 35.

134. Pueo primarily consume small mammals, but their diet also includes a variety of bird species. They forage in a variety of habitats and their prey likely varies with the habitat. Ex. A-1 at 35.

135. Pueo historically occurred on all of the southeastern Hawaiian Islands including adjacent islets. They are considered sacred by native Hawaiians, but early settlers killed them and populations had declined by the late 1800s. In the 2000s, however, populations seemed to have stabilized, although populations show episodic peaks and "die-offs." Ex. A-1 at 36.

136. Pueo are susceptible to many of the same factors that threaten other native Hawaiian birds, including loss and degradation of habitat, predation by introduced mammals, and disease. They are also susceptible to pesticide poisoning, food shortages and vehicle collisions. However, pueo persist in modified landscapes and at elevations where extensive

exposure to avian malaria and avian pox is certain, which suggests that the species is able to cope with some of these threats. Ex. A-1 at 36.

137. Pueo are rare on Oahu. Although none were detected during biological surveys for the Project, the species was detected once during pre-construction avian point count surveys and once during pre-construction radar surveys for the neighboring Kahuku Wind Project. Habitat within the Project area is similar to that at the Kahuku Wind Project and is consistent with the habitat used by pueo throughout the Hawaiian Islands. However, given their diurnal and crepuscular activity pattern, and the few recordings of use of the Project area and vicinity, the likelihood of the species breeding in the area is low. Pueo is assumed to be an irregular visitor to the Project area. Ex. A-1 at 36.

138. There is the potential for pueo to breed somewhere in the vicinity of the Project and to occasionally transit the Project are or use it for foraging while breeding. Ex. A-1 at 54.

139. Applicant requests an authorized direct take of 4 pueo and indirect take of another 4 pueo over the 21-year permit term. Ex. A-1 at 54-55.

140. Direct take could occur as a result of collision with the WTGs. Although the direct take over the 21-year permit term is not anticipated to exceed 1 pueo, the value is increased to account for uncertainty that is inherent when estimating the frequency and magnitude of a rare event over an extended time period. Therefore, the estimated direct take over the 21-year permit term is 4 pueo. Ex. A-1 at 53-54.

141. WTG collision-associated fatalities are likely to be low because (i) pueo are expected to use the Project area only as irregular visitors, (ii) pueo are highly maneuverable in flight and able to avoid collision, and (iii) given the low likelihood of breeding in the area and

that flights high above the ground are typically used only as pre-breeding display flights, pueo using the area are unlikely to fly within the rotor swept area. Ex. A-1 at 53.

142. No pueo fatalities have been documented at operational wind farms on Oahu. Conversely, pueo fatalities have occurred at the operational Kaheawa Pastures I Wind Project on Maui, where pueo were detected regularly during pre-construction surveys and where the species is much more common than on Oahu. This suggests that the risk of pueo collision with WTGs may be related to pueo density and/or breeding activity, which is either very low or non-existent in the Project area. Ex. A-1 at 53.

143. The direct take of a pueo during the breeding season may result in indirect loss of dependent chick(s) or egg(s). Based on life history information about pueo, it is calculated that the direct take of 4 adult pueo could result in the indirect take of 4 chicks/eggs. Ex. A-1 at 54-55.

144. No population estimates are available for pueo on Oahu or even more broadly in the Hawaiian Islands. The lack of systematic monitoring on Oahu makes it difficult to assess the effect that take of pueo resulting from the Project may have on the local population, but anecdotal observations suggest the Oahu population is low and any take may be of concern. Nevertheless, population-level impacts are not expected because the requested take of 4 adults and 4 chicks/eggs over 21 years is low. Ex. A-1 at 55.

145. **Avoidance and Minimization**. The HCP provides for the following measure to minimize take of the pueo.

- NPM will implement low wind speed curtailment from March – November between sunset and sunrise. Although this minimization measure is proposed to reduce the potential impacts to `ope`ape`a, it will also reduce the risk to pueo, which could transit the Project at night.
- A vehicular daytime speed limit of 25 miles per hour and a nighttime speed limit of 10 mph will be observed on the Project area roads to minimize the potential for vehicle collision with pueo.

- The selection of an unguyed, free-standing met tower maximizes the ability of pueo to detect the structure and avoid collision.
- The marking of Project transmission lines to increase visibility minimizes the potential for pueo collisions.
- Construction equipment will be at the Project site for relatively short periods of time; given the low frequency of use of the area by pueo and their ability to detect and avoid structures, the risk of collision with Project equipment is negligible.

Ex. A-1 at 54.

146. **Mitigation**. NPM will contribute $25,000 by the COD to the Endangered Species Trust Fund to be used for the express purpose of mitigating impacts to pueo. Ex. A-1 at 76-77, Appendix E.

147. Due to the low level of anticipated impact to pueo and a general desire to maximize the positive effects of investments in mitigation, DOFAW will use the Endangered Species Trust Fund to consolidate contributions for pueo mitigation from approved projects. Pooled resources can be used to fund larger management projects or resolve larger research questions targeted at the recovery of pueo on Oahu than could have been supported through smaller scale investments. Ex. A-1 at 76.

148. The funding for research and management supports a long-term effort that, among other goals, is designed to:

- Identify and understand limiting factors on Oahu;
- Develop habitat management approaches to reduce the impact of limiting factors;
- Improve predator control and habitat management techniques;
- Improve population monitoring techniques; and
- Improve risk assessment techniques for wind energy facilities.

Ex. A-1 at 76.

149. This mitigation will provide a net benefit to the species because the funding will contribute to the knowledge of the species or improve its habitat. Information developed through these efforts will fill in data gaps and contribute to the ability to adaptively manage mitigation efforts in the future. By pooling mitigation resources from multiple sources, the potential scope of research and management efforts will be increased. Ex. A-1 at 76.

150. **Measures of Success**. The mitigation measure for pueo for the Project will have been accomplished upon the following: (1) by the COD, NPM shall have made a contribution of $25,000 to the Endangered Species Trust Fund for pueo mitigation; and (2) within 6 months of the COD, NPM and DOFAW will have an agreement documenting that the use of NPM's $25,000 contribution shall be reserved for research and/or management efforts contributing to improving management, monitoring, or understanding risk factors for pueo on Oahu. Ex. A-1 at 76-77, Appendix F.

151. NPM will provide status reports of the funding for research or management efforts in annual reports to the agencies. Ex. A-1 at 77.

e. <u>`Ope`ape`a</u>

152. `Ope`ape`a (Hawaiian hoary bat) is the only fully terrestrial native mammal in the Hawaiian Islands. It is listed as endangered by both the federal and state governments. Ex. A-1 at 17.

153. The Hawaiian Hoary Bat Recovery Plan and the State of Hawai`i Comprehensive Wildlife Conservation Strategy recommend conservation of known occupied habitat, development and implementation of conservation plans that guide the management and use of forests to reduce negative known bat populations, and continued support for `ope`ape`a research. Ex. A-1 at 17.

154. `Ope`ape`a has been observed in a variety of habitats that include open pastures and more heavily forested areas in both native and non-native habitats. Typically `ope`ape`a feed over streams, bays, along the coast, over lava flows, or at forest edges. `Ope`ape`a are insectivores whose prey include a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes and termites. Ex. A-1 at 17.

155. `Ope`ape`a are known to roost solitarily in tree foliage and have only rarely been seen exiting lava tubes, leaving cracks in rock walls, or hanging from human-made structures. Roosting foliage includes hala (*Pandanus tectorius*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), pukiawe (*Styphelia tameiameiae*), Java plum (*Syzygium cumini*), kiawe (*Prosopis pallid*), avocado (*Persea Americana*), shower trees (*Cassia javanica*), ohia trees (*Metrosideros polumorpha*), fern clumps, ironwood (*Casuarina equisetifolia*); lactating female with pups on Oahu), and mature eucalyptus (*Eucalyptus spp*.) plantations. They are also suspected of roosting in stands of Sugi pine (*Cryptomeria japonica*). Ex.A-1 at 17.

156. `Ope`ape`a are found in both wet and dry areas from sea level to 13,000 feet elevation, with most observations occurring below 7500 feet elevation. Ex. A-1 at 18.

157. Although `ope`ape`a may migrate between islands and within topographical gradients on the islands, long-distance migration is not known. Seasonal and altitudinal differences in bat activity have been suggested. Research indicates that `ope`ape`a on the Island of Hawai`i use coastal lowlands during the breeding season and migrate to interior highlands during the winter. However, `ope`ape`a can also range between habitats and elevations within a single night to target optimal local foraging opportunities. Ex. A-1 at 18.

158. Breeding activity takes place between April and August with pregnancy and birth of two young (twins) occurring from April to June. Lactating females have been documented

from June to August and post-lactating females have been documented from September to December. Until weaning, young of the year are completely dependent upon the female for survival. No data are available for the percentage of `ope`ape`a young that survive to reproductive age. Ex. A-1 at 18.

159. Confirmed reports of `ope`ape`a are known from all the main Hawaiian islands except Niihau and Kahoolawe. The species is most often seen on Hawai`i Island, Maui and Kauai. Ex. A-1 at 18.

160. Today, the largest known breeding populations are thought to occur on Kauai and Hawai`i Island. Breeding was recently documented on Oahu. Ex. A-1 at 18.

161. Relatively little research has been conducted on the `ope`ape`a, and data regarding its habitat and population status are very limited. Ex. A-1 at 18.

162. Population estimates for `ope`ape`a range from hundreds to a few thousand; however these estimates are based on limited and incomplete data due to the difficulty in estimating populations of patchily distributed bats. Ex. A-1 at 18.

163. Based on the detection of bats through acoustic monitors at the Project and the observed incidental take at the nearby Kahuku Wind Project, it is concluded that `ope`ape`a use the Project area; however, bat use is expected to be low. Ex. A-1 at 19.

164. The main potential threats to `ope`ape`a are reduction in tree cover, loss of roosting habitat, roost disturbance, increases in pesticide use, reduction in prey availability due to introduction of non-native insects, and predation. However, it is unknown what effect these threats have on local population dynamics. Observation and specimen records suggest that `ope`ape`a are now absent from historically occupied areas; however, the magnitude of population decline is unknown. Ex. A-1 at 18; Ex. A-44 at § I.b.

165. The hoary bat is one of the bat species most frequently killed by WTGs in the continental United States, primarily during fall migration. Collision with WTGs has resulted in `ope`ape`a fatalities at several wind farms in Hawai`i. Ex. A-1 at 18.

166. Applicant is requesting take of a total of 51 `ope`ape`a over a 20-year term based on two tiered levels. Ex. A-1 at 43-44 & Table 7

167. The Tier 1 estimate requests a maximum take of 34 `ope`ape`a, which is the anticipated and expected total take of `ope`ape`a over the 20-year ITL term. There is inherent uncertainty in take estimates for `ope`ape`a for wind energy projects due to the limited data about `ope`ape`a. To account for that uncertainty, the HCP identifies a second tier of incidental take which authorizes take of an additional 17 bats if, for example, minimization measures such as LWSC are not as effective in reducing take of `ope`ape`a as predicted. Ex. A-1 at 41-44 and Table 7; Tr. 8/7/17 at 76:14 to 77:2 (Snetsinger).

168. The most likely potential source of direct bat mortality is a collision or barotraumas associated with an operational WTG. Ex. A-1 at 41.

169. NPM's estimates of direct take of `ope`ape`a for the Project was calculated using the per turbine fatality rate observed at the Kahuku Wind Farm and a conservatively high assumed value for unobserved take (based on Kahuku Wind Farm data), and adjusted for the potential effectiveness of LWSC in reducing collision risk. The level of effectiveness of LWSC used here was based on the estimated effectiveness of LWSC from mainland studies. To account for the uncertainty associated with the effectiveness of this measure in Hawai'i, 150 percent of the estimated take was used to develop the total requested take limit. Ex. A-27 (Snetsinger WDT) at ¶ 17.

170. According to NPM, the Kahuku Wind Farm data was selected to estimate the Project's take of `ope`ape`a because it: (i) is adjacent to the Project; (ii) has the longest operational history on O'ahu; (iii) has a similar number of WTGs as the proposed Project; and (iv) is likely to be the most similar wind energy facility to the proposed Project because it is directly adjacent to the proposed Project and has similar vegetative and topographical characteristics. *Id.* at ¶ 34; Ex. A-1 at 41; Ex. A-27 (Snetsinger WDT) at ¶¶ 12-13; *see also* Ex. A-29 (Oller WDT) at ¶ 34. 171. In selecting the Kahuku Wind Farm as a surrogate for estimating take for the Project, NPM elected not to use data from other wind farms, including the other wind farm on Oahu at Kawailoa, reasoning that the bat data from the Kahuku project is more reflective of what to expect at this Project. Vol. 1, Tr. 08/07/17 at 108:18-109:1.

172. The fact that the Project is adjacent to the Kahuku Wind Farm and shares similar vegetative and topographical characteristics are appropriate, but by NPM's own admission, not the only, bases for estimating take based on data from the Kahuku Wind Farm.

173. According to NPM, another reason for selecting the Kahuku Wind Project as a surrogate for estimating take is the similar number of WTGs (12 WTGs at Kahuku; 9 for the Project).

174. It is unknown whether the relationship between bat deaths and the number of turbines is linear. It is not something that has been studied closely. The data is analyzed under the assumption that the number of turbines to bats killed is proportional to the amount of fatalities. However, there could be factors associated with bigger projects can change relative to bats. Vol. 1, Tr. 08/07/17 at 97:12-100:2.

175. Nevertheless, in its calculation of bat mortality, NPM assumes that the number of bat deaths is directly proportional to the number of WTGs (i.e. a linear relationship). NPM

divides bat mortality per WTG at Kahuku to calculate the fatality rate and then multiplies the fatality rate by NPM's number of WTGs. Transcript Vol I at 97; Exhibit A-1 at 42.

176. Because the fatality calculation is based on an average per turbine and then multiplied by the number of turbines proposed by NPM, it appears that NPM presumes that the number of WTGs in a Project is irrelevant. If the number of WTGs is irrelevant, NPM fails to explain why its analysis was limited to data from the Kahuku Wind Project and did not consider fatalities per WTG from other wind energy projects in Hawai`i. Given the lack of information about the relationship between the size of a wind project to the number of bat fatalities, NPM should have analyzed bat mortality at other wind projects in Hawaii in estimating take for the Project, instead of relying solely on data from the Kahuku Wind Project.

177. According to NPM, it further relied on data from the Kahuku Wind Project (and elected not to use data from Kawailoa) because Kahuku had the longest operational history on Oahu.

178. NPM and KNSC disputed whether several months during which Kahuku was only partially operational should be counted in the operational period for Kahuku. KNSC argued that Applicant should not have included the months that the Kahuku wind project was only partially operational. From August 29, 2013 through January 29, 2014 the project was limited by HECO to generating a maximum of 5 MW of the possible 30 MW. Typically, during this period fewer than 12 WTGs operated in high winds, although in low winds all WTG's may have operated. Exhibit B-38 at 8. KNSC argued that the data on bat mortality collected for the five month period from August 29, 2013 through January 29, 2014 is not representative or comparable to other data from the Kahuku wind power facility because the facility was operating at 1/6 of its capacity and

all the WTGs were not spinning as much as they normally do. *Id.*; Transcript Vol II at 195 (Fretz).

179. Snetsinger, however, testified that it is reasonable to include the 5 months where Kahuku was partially operational as long as those are generally consistent with the operations that are ongoing at the turbines when bats are at risk and additional conservative assumptions are included in the estimate to account for uncertainty. Vol. 1, Tr. 08/07/17 at 90:3-12; *see also* Ex. B-38; Ex. A-55; Exs. A-8 & A-9. Furthermore, the Kahuku Wind Farm annual report states that during the 5 month period when Kahuku was partially operational up to all permitted turbines occurred when wind speeds were low, which is the time that bats are most vulnerable to collision. Vol. 1, Tr. 08/07/17 at 94:14-18; *see also* Ex. B-38 at 8. NPM argues that was reasonable to include the data from the time Kahuku was not fully operational as searches were still going on; and bats are most active and forage in low wind conditions, and therefore at those low wind speeds, is the likely period of greatest risk to bats. Vol. 1, Tr. 08/07/17 at 94:11-18.

180. Whether the partially operational period is included or excluded, the difference in operational periods between Kahuku and Kawailoa amounts to no more than 6 months. NPM has failed to articulate why this 6-month period is a rational basis for rejecting data from Kawailoa and relying exclusively on data from Kahuku.

181. Other wind facilities in Hawai`i have been in operation for longer periods. NPM failed to provide any analysis on the relationship between the length of operational period to bat mortality that justifies its reliance solely on data from the Kahuku Wind Project and exclusion of data from other Hawai`i wind projects.

182. The Kahuku wind power facility consists of twelve WTGs with a maximum height of 128 m. Exhibit B-23 at 8. The Kawailoa wind power facility consists of thirty WTGs

with a maximum height of 150.5 m. Exhibit B-35 at 13. The Project will have 9 WTGs with maximum height of 200 m.

184. According to the Applicant, the use of fewer, but taller WTGs was selected in response to state agency comments as well as community concerns about visual impacts. Vol. 1, Tr. 08/07/17 at 22:8-12. A visual impact analysis of the wind turbines at 656 feet tall was done. Vol. 1, Tr. 08/07/17 at 22:18-20; Ex. A-12 § 4.16.

185. Applicant contends that notwithstanding the difference in height between the WTGs at Kahuku and the Project's WTGs, the Kahuku Wind Project is an appropriate surrogate because there is no direct correlation between turbine height and take. Vol. 1, Tr. 08/07/17 at 54:15-24; 72:4-11; *see* Ex. A-10.

186. Applicant relies on a research article by Zimmerling and Francis, *Bat Mortality Due to Wind Turbines in Canada*, printed in the Journal of Wildlife Management. The authors stated that they found no relationship between bat mortality/turbine and height of wind turbines. However, the authors noted that there was relatively little variation in the height of the wind turbines in the sample for which they had data, with most of the turbines being between 117 m and 136 m. Ex. A-10 at 5.

187. Hein and Schirmacher, in their 2016 article *Impact of Wind Energy on Bats*, note that taller turbines are associated with larger rotor-swept areas, which presumably contribute to greater fatality rates. They note that numerous studies support the hypothesis that taller turbines are associated with greater fatalities of bats. Although this article was published after the final HCP had been drafted, the article cited to studies conducted in 2007, 2008, and 2009 regarding the relation between turbine height and bat mortality. Ex. B-1 at p. 24. See also Ex. A-50 at 5.

188. A 2007 publication by Barclay, et al, *Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height*, concluded that minimizing tower height may help minimize bat fatalities and, conversely, that replacing older, smaller turbines with fewer larger ones may result in increased numbers of bat fatalities. Ex. B-7.

189. There is agreement that turbine height alone may not account for differences in bat mortality, but it is a factor to be considered in analyzing impact on bats. Ex. B-1 at 24; Ex. A-44 at § III.a.; Vol. 2, Tr. 08/08/17 at 192:6-25, 194:10-13 (Fretz).

190. In relying on the Kahuku Wind Project as a surrogate for the Project, Applicant failed to consider the difference in turbine height in estimating take for the Project. For example, although the WTGs at Kawailoa are taller than Kahuku's (but still not as tall as the maximum proposed for the Project) Applicant elected not to use data solely from Kahuku and not Kawailoa. Contrary to Applicant's contention, the best scientific data does not support the hypothesis that there is no correlation between turbine height and take.

191. To measure compliance for Hawaiian hoary bat take at Hawaiʻi wind farms, DOFAW and USFWS estimate the take (and associated mitigation requirement for this take) at an 80% upper credible limit. Ex. A-1 at 40-56; Ex. A-12 at 4-109 to 4-122. That is, regulatory agencies are 80% confident that Applicant (and each other wind farm) will mitigate for more bats than it will take. Vol. 1, Tr. 08/07/17 at 81:11-20; 109:2-18.

192. However, existing data reveals that `ope`ape`a have been taken at a faster rate than predicted. Vol. 1, Tr. 08/07/17 at 84:6-10. This is an indication that DOFAW and USFWS, at least in the past, have underestimated take.

193. It may be that the location of the Kahuku Wind Farm and the similarities in topography and vegetation are the most influential factors in estimating the Project's potential

take of `ope`ape`a. By relying solely on data from the Kahuku Wind Project, without discussing data from other wind projects or sufficiently articulating why data from other wind projects are not applicable to the Project, NPM failed to meet its burden of showing that the best available scientific information was used in estimating take.

194. Because very little is known about the population status of `ope`ape`a (estimates range from a few hundred to a few thousand), and given the fact that take of `ope`ape`a by wind energy facilities may have been underestimated in the past, a robust analysis of potential take is critical. By relying solely on the Kahuku Wind Project as a surrogate and electing not to consider data from other wind facilities on Oahu or the other islands, and by failing to consider the impact of turbine height on bat mortality, the estimated take set forth in the HCP is not reliable enough for the Board to determine that the HCP will not jeopardize the continued existence of `ope`ape`a. HRS 195D-21(c), HRS 195D-21(c)(1).

195. **Avoidance and Minimization.** `Ope`ape`a roost in non-native and native woody vegetation that is at least 15 ft. (4.5 m) or taller. To minimize potential impacts to `ope`ape`a, woody plants greater than 15 ft. (4.5 m) tall will not be removed or trimmed between June 1 and September 15 during the installation and ongoing maintenance of the Project structures. Ex. A-1 at 38-40.

196. Barbed wire will not be used on perimeter fences required to secure Project infrastructure to avoid the risk of entangling bats. Ex. A-1 at 38-40.

197. **LWSC**. To reduce the risk of take of `ope`ape`a, the HCP provides for the implementation of low wind speed curtailment (“LWSC”). The HCP provides that the cut-in speed for LWSC will be 5 meters/second ("m/s") and feathering of blades below cut-in speed

between sunset and sunrise, March – November, and as otherwise necessary and determined to be appropriate through Adaptive Management. Ex. A-1 at 39.

198. Curtailment refers to a practice in which wind energy is available, but is not being collected and supplied to the grid. Curtailment can be implemented by the wind operator as an operational minimization measure. This involves increasing the wind speed at which turbines will "cut-in" and start producing power, as bat collisions happen at a much higher rate when wind speed are low. Although wind turbines do not generate power below the cut-in speed, turbine blades continue spinning and therefore still pose a collision risk to wildlife. To combat this risk, blades are often feathered, which means they are turned parallel to the wind and therefore will not spin below the cut-in speed, although they may rotate very slowing (called free-wheeling). Ex. A-44 at 7.

199. Research suggests that more bat fatalities occur during relatively low-wind periods. Non-spinning turbine blades and turbine towers do not kill bats. Raising turbine cut-in speed (i.e., the lowest wind speed at which turbines generate power to the utility system) above the manufactured cut-in speed (usually 3.5 – 4.0 meters per second on modern turbines) renders turbines non-operational until the higher cut-in speed is reached and turbines then begin to spin and produce power. Thus, raising turbine cut-in speed during low-wind periods should reduce bat kills. Ex. A-5 at 2.

200. Based on the best available science low wind speed "[c]urtailment is currently the primary minimization measure implemented by wind farms in the U.S., including those here in Hawai‘i," Ex. A-44 § IV.c. at PDF page 7, for reducing incidental take risks, and is a wind industry best management practice highly effective at minimizing bat take. Vol. 1, Tr. 08/07/17 at 14:21-25.

201. Various studies in the US and Canada have looked at the impacts of raising cut-in speeds on number of bat fatalities. Result from studies conducted across numerous ecosystems and facilities, have consistently shown a decrease in fatalities of about 50 percent or more once cut-in speeds are equal to or greater than 5.0 meters per second. Ex. A-44 at 7.

202. The LWSC controversy in this case is whether the cut in speed for LWSC should be 5 meters/second as proposed by the HCP or the higher cut in speed of 6.5 m/s. Increasing cut-in speed from 5 to 6.5 m/s would increase the amount of time that turbine blades are not spinning or feathering. However, the studies are inconclusive as to whether there is a significant difference in minimizing bat fatalities when the cut-in speeds are increased from 5 to 6.5 m/s.

203. In its 2008 annual report, the Bats and Wind Energy Cooperative stated that their data indicated no significant difference in fatalities between these two changes in cut-in speed (5.0 m/s and 6.5 m/s). But with low statistical power to detect such a difference, the report concluded that further research is needed to determine whether lower changes in cut-in speed may provide the same biological effects as higher cut-in speeds with less financial cost. Ex. A-6 at 27.

204. A study reported in Frontiers in Ecology and the Environment noted that contrary to prediction, there was no difference in bat fatalities between the 5.0 and 6.5 m/s treatments during either year of the study, and curtailment at 5.0 m/s proved to be far more cost effective. However, the authors found little differentiation in the amount of time different cut-in speed treatments were in effect, which may explain in part why they found no difference in bat fatalities between the two treatments. Ex. A-5 at 6-7.

205. The Fowler Ridge Wind Energy Facility (Indiana) study is the first to demonstrate that bat casualty rates were not only significantly different between control and treatment

turbines, but that bat casualty rates were significantly different between cut-in speeds raised to 5.0 m/s (50% reduction in overall bat mortality) versus turbines with cut-in speeds raised to 6.5 m/s (78% reduction in overall bat mortality). Ex. B- 15 at 4, 70.

206. DOFAW's December 2015 Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance Document ("Bat Guidance") recommends a minimum cut-in speed of 5.0 m/s, increasing to a higher cut-in speed through adaptive management if the rate of bat take is higher than initially expected. Ex. A-44 at § IV.c.; Vol. 1, Tr. 08/07/17 at 139:7-143:25.

207. The inference from the Bat Guidance recommendation is that higher cut-in speeds afford greater protection, i.e., cut-in speed of 6.5 m/s is likely to result in less bat fatalities than a cut-in speed of 5 m/s. Fretz concurred that curtailing wind production at higher speeds could reduce bat take. Vol. 2, Tr. 08/08/17 at 200:4-6.

208. HRS § 1954(g)(1) requires the applicant to minimize and mitigate the impacts of the take to the maximum extent practicable. Although, studies to date are inconclusive as to whether there is a significant difference in minimizing bat fatalities when the cut-in speeds are increased from 5 to 6.5 m/s, there some evidence that it does. Conversely, there is no evidence that cut-in speed of 5 m/s is more effective in minimizing impacts to bats than cut-in speed of 6.5 m/s. Moreover, the inferences are that curtailing wind production at higher speeds could reduce bat take. Therefore, the best scientific knowledge currently available suggests that increasing cut-in speed to 6.5 m/s, rather than 5 m/s, would minimize impacts to the maximum extent.

209. Increasing cut in speed reduces operating time to generate power. Lost power production resulting from experimental treatments was markedly low when considering total

annual productivity, but power loss was three times higher for the 6.5 m/s change in cut-in speed as compared with the 5.0 m/s treatment. Ex. A-5 at 2, 6-7.

210. Applicant did not provide evidence that increasing cut-in speed from 5 m/s to 6.5 m/s is not practicable.

211. **Mitigation**. There are separate mitigation actions associated with Tier 1 and Tier 2 levels. Tier 1 mitigation will be implemented upon the development of the Project. Tier 2 mitigation will be implemented prior to reaching the Tier 1 take estimate if it is determined that the limits of Tier 1 may be exceeded before the 20-year term of the ITL. Tr. Vol. 1, 8/7/17 at 76:14 to 77:7; Ex.A-1 at 44, Ex. A-1 at 65-67, Snetsinger WDT at ¶16.

212. Mitigation measures provide for habitat improvement and to prevent degradation of existing `ope`ape`a habitat at Poamoho Ridge. Ex.A-1 at 59; Snetsinger WDT at ¶8. Such measures involve the removal of invasive species and pigs to provide an improved natural habitat and additional food sources for `ope`ape`a. Mitigation measures also prevent the degradation of forest that support roosting activities. Tr. 8/7/17 at 112:14 to 113:5; Tr. 8/8/17 at 202-22 to 203:7, 224:10-13.

213. The HCP provides that NPM will contribute towards habitat improvement at Poamoho Ridge by providing annual funds to the Ko`olau Mountains Watershed Partnership ("KMWP") or another mutually agreed upon organization for an 8-year period to cover the costs of two full-time employees per year performing forest restoration, management, and monitoring activities including fence maintenance, bat acoustic monitoring, pig/goat control and monitoring, and invasive plant removal and monitoring within the fenced area, as well as needed supplies and helicopter time. If Tier 2 mitigation is required, habitat improvement contributions will continue

for an additional four years. It is anticipated that the management work will be implemented by KMWP. Ex. A-1 at 63.

214. By removing invasive species, fencing to limit predators, removing pigs, and maintaining and improving the existing known habitat on Poamoho Ridge, NPM is providing an improved natural habitat for bats which presumably would provide additional food resources, thereby improving `op`ape`a survival and productivity and contributing to an increased likelihood of the survivability of the species. Vol. 1, Tr. 08/07/17 at 111:23-112:24. 215. Due to the lack of information available for the Hawaiian hoary bat, Applicant used surrogate measures to determine what would be appropriate mitigation for `ope`ape`a based on guidance from the Agencies as well as based on the ESRC Bat Guidance. Vol. 1, Tr. 08/07/17 at 118:16-20. Such measures include fencing of habitat, fence maintenance, invasive weed control, and native reforestation, employee field observation and site maintenance functions which are expected to achieve a net benefit to `op`ape`a by providing a sustained area of native high quality ecosystem. Vol. 1, Tr. 08/07/17 at 117:21-118:20; Ex. A-29 (Oller WDT) at ¶¶ 28-32, 95-97.

216. Bat mitigation measures are still in their early stages and are being implemented, and monitoring is ongoing. Therefore, it is premature to conclude that the proposed mitigation measures will not benefit the Hawaiian hoary bat. Vol. 1, Tr. 08/07/17 at 124:1-7. By the same token, it is premature to conclude that the proposed mitigation measures will be a net benefit to `ope`ape`a. Fretz acknowledged that there is no existing definitive data that shows fence maintenance, restoration of native forests, invasive species removal, pig removal will directly increase the bat population. Vol. 2, Tr. 08/08/17 at 203:14-204:11.

217. A study of removal of axis deer and goats from the Kahikinui Forest Reserve and Nakula Natural Area Reserve indicated that the `ope`ape`a populations declined after removal.

See Ex. B-20. It is unknown whether there is a causal relationship between the removal of these animals and the decline in bat populations. Vol. 2, Tr. 08/08/17 at 205:15-206:2; Snetsinger Vol. 1, Tr. 123:10-124:7.

218. There is no statistical data or studies to demonstrate that the `ope`ape`a population is likely to increase with the mitigation measures proposed by the HCP. However, the ESRC believes that the proposed mitigation measures are appropriate under the current conditions and scientific knowledge. Vol. 2, Tr. 08/08/17 at 207:3-9. 219. Fretz elaborated that there is not much evidence from the existing wind energy projects on whether or not the mitigation measures used by those projects have increased the bat population. Because gathering this type of data and associated habitat management are long-term efforts, results will take time to manifest. Therefore, even if results are not readily apparent, the ESRC wants to continue the management measures for another 5, 10, or 20 years to allow for analysis of such results and measures. These projects are being carried out because the agencies expect to get a result over the long term, and when the future results are apparent, the agencies want to understand the effect and apply it to ongoing and future mitigation strategies. Vol. 2, Tr. 08/08/17 at 208:8-18.

220. Mitigation includes funding for research by NPM targeting one of the research priorities in accordance with a research plan approved by DOFAW and USFWS. Ex. A-1 at 58.

221. NPM will either independently fund a research project or will contribute funding to expand an existing research project. NPM will contribute $100,000 of research funding for Tier 1 mitigation and an additional $50,000 if Tier 2 mitigation becomes necessary. Within 6 months of the COD, NPM and the agencies will have agreed on the research proposal and funding shall occur within 6 months thereafter. Planning for research projects for Tier 2 will

commence when 75 percent of the take associated with Tier 1 is reached. Ex. A-1 at 62, Appendix F.

222. The Hawaiian Hoary Bat Recovery Plan identifies research as one of the primary actions needed to move toward recovery and delisting of the species. Priority research areas include: (i) \`ope\`ape\`a population size and trend and population distribution on each island; (ii) habitat selection and suitability for roosting, foraging, and breeding; (iii) diet studies including prey selection, prey presence/absence and availability; and (iv) in-depth monitoring of bat response to a variety of bat mitigation projects.

223. Research is an acceptable form of mitigation if information gained through research will inform and benefit future mitigation efforts. Ex. A-44; Tr. 8/7/17 at 113:19 to 114:5; Tr. 8/8/17 at 202:22 to 203:7, 207:10 to 208:1; 208:8-18, 224:10-13.

224. The ERSC Bat Guidance includes support for research targeted at improving our knowledge of the \`ope\`ape\`a so that future mitigation projects can leverage results to improve the efficacy of mitigation efforts. Snetsinger WDT at P29.

225. For example, if new research results point to increased reductions in \`ope\`ape\`a fatalities by including other weather variables in curtailment triggers, Applicant could adjust the approved strategy in consultation with DOFAW and USFWS to further reduce impacts.

226. An alternative mitigation proposal being considered for the conservation of \`ope\`ape\`a habitat is the acquisition of unprotected land to safeguard it from development. Acquisition of land for this purpose would mitigate impacts beyond the permit term. The selection of any acquisition property would require the approval of USFWS, DOFAW, and the ESRC. Ex. A-1 at 61, 65.

227. **Measures of Success**. The HCP identifies the completion of tasks, such as, but not limited to, having an approved research plan, timely funding the Poamoho Ridge habitat improvement plan, and having conducted acoustic bat monitoring. The HCP also lists monitoring of efforts in removal of pigs and goats and invasive plants. Ex. A-1 at 65-66. The HCP is silent as to what happens in the event that pigs, goats and invasive plants are not removed to the extent and in the timeframe provided in the management plan. See discussion of Adaptive Management below.

F. Adaptive Management

228. "Adaptive Management" is defined by the U.S. Department of the Interior as "a structured approach to decision making in the face of uncertainty that makes use of the experience of management and the results of research in an embedded feedback loop of monitoring, evaluation, and adjustments in management strategies." Ex. A-1 at 86.

229. Uncertainties include a lack of biological information for the Covered Species, lack of knowledge about the effectiveness of mitigation or management techniques, or doubt about the anticipated effects of the Project. Ex. A-1 at 86.

230. Adaptive Management is a required component of all HCPs. An adaptive management strategy must specify the actions to be taken periodically if the plan is not achieving its goals. *See* HRS § 195D-21(b)(2)(H).

231. An adaptive management strategy allows for the incorporation of new information into conservation and mitigation measures during HCP implementation. It allows for flexibility to adopt and implement improvements in mitigation and minimization plans or avoidance and minimization measures by adjusting approaches to take advantage of the latest research studies

and technologies. Such flexibility allows for HCPs to incorporate current best science approaches to mitigation and reduction of impacts. Ex.A-1 at 86.

232. Section 9.5 of the HCP discusses its Adaptive Management strategy. In addition to discussing implementation of Tier 2 mitigation for `ope`ape`a if take exceeds the number allowed in Tier 1, the HCP states that the NPM "will implement the use of proven new technologies or measures to minimize take as approved by and reasonably determined to be necessary by USFWS and DOFAW in consultation with Na Pua Makani Power Partners." Ex. A-1 at 86-87; Ex. A-29 (Oller WDT) at ¶ 85.

233. According to the Applicant, the annual reporting requirements also provide an opportunity to engage with DOFAW, USFWS, and the ESRC to address challenges in achieving the stated goals. Ex. A-29 (Oller WDT) at ¶ 86.

234. Adaptive Management, as proposed in the HCP, is considered when an observed fatality of a Covered Species occurs, when challenges to meeting measures of success are identified, and during the annual report review process. *See* Vol. 1, Tr. 08/07/17 at 63:3-23. When an observed fatality for a Covered Species occurs, the first question addressed with the Agencies is, "[i]s there any adaptive management that is needed?" (i.e., is there something we could have done to prevent this?). *See id.* For example, if a Hawaiian hoary bat fatality is observed outside of the period when LWSC is being implemented, Applicant would consult with USFWS and DOFAW to consider if expanding the period of LWSC is appropriate. In general, the answer to this question would be yes, there is a risk that we may be able to reduce by expanding the period of LWSC; however, expansion of this period may not always be appropriate (*e.g.*, if the observed fatality occurs during an anomalous weather event). Similarly,

permitting challenges for the Hamakua Marsh fence might suggest adapting the approaches described in the HCP by adjusting the fence parameters. *See* Ex. A-1 at 71-74.

235. The HCP's adaptive management strategy focuses on avoidance and minimization measures and on Permittee's ability to comply with mitigation requirements (see examples above). There is no discussion, however, on revising mitigation plans when (i) meaningful measures of success are not being met, and (ii) new information comes to light that may indicate different mitigation measures that may be more effective in protecting the species and promoting its survivability. Oller explained an informal process between the Permittee and the agencies that rely on voluntary cooperation but without coercive or enforcement powers by the agencies, except in cases of violation of the ITL or HCP. Tr. 8/7/17 at 63:3 to 67:25 (Oller).

236. Most of the measures of success included in the HCP are not conducive to adaptive management strategies. For example, by contributing to a pool of money for `a`o conservation research or projects to be carried out by USFWS, there is no adaptive management strategy under the HCP in the event that the management project that was funded turns out to be ineffective. See FOF # 52.

237. Even where adaptive management strategies are practical, the HCP fails to specify actions that will be taken. For example, mitigation for take of Hawaiian waterbirds includes partial fencing of Hamakua Marsh and funding for a staff biologist to do public education and monitoring. The HCP does not discuss any adaptive management strategy in the event that fencing, monitoring and public education are not successful in reducing the number of predators entering the marsh, the amount of trash in the parking lot adjacent to the marsh, or increasing the nesting opportunities within the marsh.

238. Research is an acceptable form of mitigation if information gained through research will inform and benefit future mitigation efforts. Given the limited knowledge about `ope`aope`a, research is an appropriate form of mitigation provided that the knowledge gained from research will inform and benefit future mitigation efforts. The HCP's mitigation strategy calls, in part, for funding for research but relies on other, future wind projects to implement mitigation strategies arising out of the research. The requested ITL is for a 21-year period. Moreover, currently there is ongoing research on `ope`ape`a. It is foreseeable, therefore, that during the permit term, research efforts may conclude that protecting habitats other than Poamoho Ridge may be more effective in the survival of `ope`ape`a on Oahu, especially as current knowledge indicate that `ope`ape`a use a variety of different, including disturbed, habitats. Adaptive management should enable revisions in NPM's mitigation plans due to new research findings. The HCP, however, does not include such adaptive management strategies.

G. Funding Commitments

239. As required by HRS § 195D-4(g)(2), Applicant has adequate funding for the HCP and will provide any required financial guarantee tool requested and approved by the Board (*e.g.*, an irrevocable letter of credit). Ex. A-1 at § 9.4; Ex. A-29 (Oller WDT) at ¶ 121. The Project's operational mitigation funds will be deposited in the endangered species trust fund created by HRS § 195D-31. Ex. A-1 at § 9.4. The funds will be adequate to ensure monitoring of the Covered Species by the State and to ensure that Applicant takes all actions necessary to minimize and mitigate the impacts of the take. Ex. A-29 (Oller WDT) at ¶ 122. Funding assurances include a budget for DOFAW to conduct compliance monitoring, if needed. *Id.* These funds will be used by DOFAW to verify Applicant's compliance with the terms of an approved HCP and corresponding ITL. *Id.*

II. CONCLUSIONS OF LAW

1. HRS § 195D-21(b)(1)(A) requires that the HCP further the purpose of HRS Chapter 195D by protecting, maintaining, restoring, or enhancing identified ecosystems, natural communities, or habitat types upon which endangered, threatened proposed or candidate species depend within the area covered by the plan.

1.a. **`A`o**. The HCP identifies a number of avoidance and minimization measures to protect the `a`o's use of the Project area. FOF 53. The mitigation proposal for `a`o is not aimed toward ecosystems within HCP area; however, given the low potential for mitigation efforts on a small scale to be successful on Oahu, funding for protection, maintenance, restoration or enhancement of ecosystems in area where `a`o breed would be more effective for species protection and enhancement. Contribution of funds to NFWF for `a`o mitigation in accord with the USFWS Newell's Shearwater Recovery Plan, which identifies predator control and expanding knowledge of the species' status and distribution, are aimed at protecting, maintaining, restoring or enhancing ecosystems, natural communities or habitat types upon which `a`o depend. FOF 54-56.

1.b. **Hawaiian Waterbirds**. Habitat loss and degradation and predation by introduced animals are the primary threats to Hawaiian waterbirds. Appropriate habitat management of core wetlands is the first recovery criterion for these waterbirds. The HCP mitigation proposal of contributing to the design and construction of a stretch of fence along Hamakua Marsh and funding for a half-time staff biologist to conduct monitoring and public education should enhance habitat important for the survival and recovery of these waterbirds. FOF 105-110.

1.c. **Nene**. The HCP identifies a number of avoidance and minimization measures to minimize take of nene in the Project area. FOF 123. The mitigation proposal is for NPM to contribute $50,000 towards fence construction at JCNWR. As predation by non-native mammals is the greatest factor limiting nene populations, implementation of the HCP should enhance habitat important for the survival and recovery of nene.

1.d. **Pueo**. The HCP identifies a number of avoidance and minimization measures to minimize pueo collisions with Project's WTGs and met tower. FOF 145. The mitigation proposal for pueo is not aimed towards habitats within the HCP area. However, given the low level of anticipated impact to pueo by the Project, a pooling of resources to fund larger management projects or resolve larger research questions targeted at the recovery of pueo on Oahu would be more effective for species protection and enhancement. FOF 146-149.

1.e. **`Ope`ape`a**. By providing for LWSC at 5 m/s, instead of 6.5 m/s, the HCP fails to minimize impacts to `ope`ape`a to the maximum extent practicable, and, therefore, may not be protecting or maintaining the habitat used by `ope`ape`a (i.e., the Project area) as required under HRS § 195D-21(b)(1)(A). FOF 197-210. Because of limited knowledge about `ope`ape`a, it cannot be concluded that the proposed mitigation of improvement of habitat at Poamoho Ridge will protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types upon which `ope`ape`a depend. FOF 216. As the HCP does not include an effective adaptive management strategy for revising mitigation measures if future research reveals that different mitigation measures would be more effective in protecting and maintaining habitat used by `ope`ape`a, FOF 228-238, the HCP does not meet this criterion with respect to `ope`ape`a.

2. HRS § 195D-21(b)(1)(B) requires that the HCP increase the likelihood of recovery of the Covered Species.

2.a. **`A`o**. The goal of the USFWS Newell's Shearwater Recovery Plan is to promote the recovery of the `a`o. Contribution of funds to NFWF for `a`o mitigation is in accord with the Recovery Plan. FOF 54-56.

2.b. **Hawaiian Waterbirds**. Fencing of Hamakua Marsh and public education about predation threats to waterbirds address the primary threats to these waterbirds, and, therefore, the mitigation strategies in the HCP will increase the likelihood of recovery of these endangered waterbirds. FOF 105-110.

2.c. **Nene**. As predation is the greatest factor limiting nene populations, contributing to the fencing of JCNWR, a habitat shown to be suitable for breeding nene, is likely to increase the likelihood of recovery of nene. FOF 116, 124-136.

2.d. **Pueo**. Given the low level of anticipated impact to pueo by the Project, a pooling of resources to fund larger management projects or resolve larger research questions targeted at the recovery of pueo on Oahu is probably the most effective means of increasing the likelihood of recovery of pueo. FOF 146-149.

2.e. **`Ope`ape`a**. Mitigation proposed for `ope`ape`a includes contributing towards habitat improvement at Poamoho Ridge by providing annual funds to the KMWP and funding for research. FOF 213, 220. Because of limited knowledge about `ope`ape`a, it cannot be concluded that the proposed mitigation of improvement of habitat at Poamoho Ridge will increase the likelihood of recovery of `ope`ape`a. FOF 216. As the HCP does not include an effective adaptive management strategy for revising mitigation measures if future research reveals that different mitigation measures would be more effective in protecting and maintaining habitat used by `ope`ape`a, FOF 228-238, the HCP does not meet this criterion with respect to `ope`ape`a.

3. In accordance with HRS 195D-21(b)(1)(C), the HCP identifies geographic area encompassed by the HCP; ecosystem, natural communities, or habitat types within the Plan area; endangered, threatened, proposed and candidate species known or reasonably expected to be present in those ecosystems, natural communities or habitat types in the Plan area. FOF 42, 43.

4. In accordance with HRS § 195D-21(b)(2)(B), the HCP identifies activities contemplated to be undertaken within the Plan Area with sufficient detail to allow DLNR to evaluate the impact of the activities on the particular ecosystems, natural communities, or habitat types within the plan area. FOF 30-39.

5. The HCP must identify the steps that will be taken to minimize and mitigate all negative impacts, including without limitation, the impact of any authorized incidental take, with consideration of the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed; and the funding that will be available to implement those steps. HRS § 19521(b)(2(C).

5.a. **`A`o**. See COL 1.a. and 2.a., above. Should the maximum requested take of 4 adult/fledgling `a`o occur, it should not have a population-level impact, as it would represent an increase in mortality rate of 0.01 percent of the population distributed over the 21-year permit term. FOF 52.

5.b. **Hawaiian Waterbirds**. See COL 1.b. and 2.b., above. Should the requested take of the four waterbird species occur over the 21-year permit term, it should not have a population-level impact on the respective populations. Each of these species has a statewide population that is stable or increasing. Therefore, no population is likely to be particularly sensitive to losses on the order of one bird every 3 to 5 years. FOF 104.

5.c. **Nene.** See COL 1.c. and 2.c., above. Should the maximum requested take of 6 nene occur, it should not have a population level impact, as it would represent an increase in mortality rate of less than 0.3 percent of the population distributed over the 21-year permit term. FOF 122.

5.d. **Pueo**. See COL 1.d and 2.d., above. No population estimates are available for pueo on Oahu or even more broadly in the Hawaiian Islands. The lack of systematic monitoring on Oahu makes it difficult to assess the effect that take of pueo resulting from the Project may have on the local population, but anecdotal observations suggest the Oahu population is low and any take may be of concern. Nevertheless, population-level impacts are not expected because the requested take of 4 adults and 4 chicks/eggs over 21 years is low. FOF 144.

5.e. **\`Ope\`ape\`a**. See COL 1.e and 2.e., above. Because very little is known about the population status of \`ope\`ape\`a (estimates range from a few hundred to a few thousand), and given the fact that take of \`ope\`ape\`a by wind energy facilities may have been underestimated in the past, a robust analysis of potential take is critical. By relying solely on the Kahuku Wind Project as a surrogate and electing not to consider data from other wind facilities on Oahu or the other islands, and by failing to consider the impact of turbine height on bat mortality, the estimated take set forth in the HCP is not reliable enough for the Board to determine the cumulative impacts on \`ope\`ape\`a. FOF 194.

6. Pursuant to HRS § 195D-21(b)(2)(D), Appendix F and Section 9.4 of the HCP identifies those measures or actions proposed to be undertaken to protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types within the plan area; a schedule for implementation of the measure or actions; and an adequate funding source to ensure that the

actions or measures, including monitoring, are undertaken in accordance with the schedule. See other COL, however, regarding the adequacy of such proposed measures or actions.

7. HRS § 195D-21(b)(2)(E) provides that the HCP must be consistent with the goals and objectives of any approved recovery plan for any endangered or threatened species known or reasonably expected to occur in the ecosystems, natural communities or habitat types in the plan area.

7.a. **`A`o**. Contribution of funds to NFWF for `a`o mitigation is in accord with the USFWS Newell's Shearwater Recovery Plan Recovery Plan. FOF 54-56.

7.b. **Hawaiian Waterbirds**. The proposed mitigation for Hawaiian waterbirds is consistent with the Revised Hawaiian Waterbirds Recovery Plan, completed in 2011, and the State of Hawai`i`s Comprehensive Wildlife Conservation Strategy which recommend preservation of wetland habitat and management of introduced predators in priority wetlands. FOF 59.

7.c. **Nene.** Contributing to the fencing of JCNWR is consistent with the recommended strategies contained in the draft Hawaiian Goose Recovery Plan, revised in 2004, and the State of Hawai`i Comprehensive Wildlife Conservation Strategy which include identifying and protecting Hawaiian goose habitat, restoring and enhancing habitat, controlling alien predators, and minimizing Hawaiian goose conflicts with human activities. FOF 114.

7.d. **Pueo**. Contributing to the pool of resources to fund larger pueo management projects or resolve larger research questions is consistent with the State of Hawai`i's Comprehensive Wildlife Conservation Strategy which recommends a combination of conservation actions, monitoring and research. These recommendations include continuing conservation efforts at refuges and wildlife sanctuaries, expanding survey efforts to monitor populations status and trends on Oahu, and conducting research into limiting factors such as "sick owl syndrome" and vehicle collisions. FOF 131.

7.e. **`Ope`ape`a**. Mitigation proposed for `ope`ape`a includes contributing towards habitat improvement at Poamoho Ridge by providing annual funds to the KMWP and funding for research, FOF 213, 220, which accords with the Hawaiian Hoary Bat Recovery Plan and the State of Hawai`i Comprehensive Wildlife Conservation Strategy, which recommend conservation of known occupied habitat, development and implementation of conservation plans that guide the management and use of forests to reduce negative known bat populations, and continued support for `ope`ape`a research. FOF 153.

8. Pursuant to HRS § 195D-21(b)(2)(F) the HCP must provide reasonable certainty that the ecosystems, natural communities, or habitat types will be maintained in the plan area, throughout the life of the plan, in sufficient quality, distribution, and extent to support within the plan area those species typically associated with the ecosystems, natural communities, or habitat types, including any endangered, threatened, proposed, and candidate species known or reasonably expected to be present in the ecosystems, natural communities, or habitat types within the plan area.

8.a. See COL 1.a. through 1.e.

9. The HCP must contain objective, measurable goals, the achievement of which will contribute significantly to the protection, maintenance, restoration, or enhancement of ecosystems, natural communities, or habitat types; time frames within which the goals are to be achieved; provisions monitoring (such as field sampling techniques), including periodic monitoring by representatives of DLNR or the ESRC, or both; and provisions for evaluating progress in achieving the goals quantitatively and qualitatively. HRS § 195D-21(b)(2)(G)

9.a. Most of the measurements of success in the HCP cannot be said, when achieved, to contribute significantly to the protection, maintenance, restoration or enhancement of ecosystems, natural communities, or habitat types. Instead, success is most often measured by the contribution of money, without any evaluation of whether the use of the money actually contributed significantly to the survival or recovery of the Covered Species. While in some cases, the contribution of money is the most practicable measure of success, in other areas, there should be more meaningful measures to determine whether the mitigation measures are successful in contributing to the survival and recovery of the Covered Species.

9.b. **`A`o.** The contribution of funds should not be a measure of success because contributing money does not, in and of itself, assure the protection, maintenance, restoration or enhancement of ecosystems, natural communities or habitat types required to support the survival and recovery of the `a`o. However, given that (i) the pooling of monetary resources to carry out the statewide `a`o recovery plan is determined to be the most effective means of protecting the `a`o and promoting its survival and recovery, (ii) that carrying out the recovery plan will be conducted by governmental agencies and not NPM, the contribution of funds by NPM is the most practicable measure of success in this instance. FOF 54-58.

9.c. **Hawaiian Waterbirds**. The HCP proposes to measure success by timely fence construction and funding for fence maintenance and a half-time staff biologist. FOF 111. These actions, however, cannot be cannot be said, when achieved, to contribute significantly to the protection, maintenance, restoration or enhancement of ecosystems, natural communities, or habitat types. Meaningful measures of success should include assessments of the (i) effectiveness of the fence in reducing predation or improving breeding habitat, (ii) staff biologist's engagement with the public regarding the protection of waterbirds, and (iii) whether monitoring activities contribute towards improving habitat for waterbirds. These types of measurements of success are not included in the HCP, FOF 112, and thus, are not compliant with HRS § 195D-21(b)(2)(G).

9.d. **Nene**. The contribution of funds should not be a measure of success because contributing money does not, in and of itself, assure the protection, maintenance, restoration or enhancement of ecosystems, natural communities or habitat types required to support the survival and recovery of the nene. However, given that (i) the pooling of monetary resources for habitat management at JCNWR, which contains suitable nesting habitat, is determined to be the most effective means of protecting the nene and promoting its survival and recovery, (ii) that the management of JCNWR is under the control of USFWS and not NPM, the contribution of funds by NPM is the most practicable measure of success in this instance. FOF 124-129.

9.e. **Pueo**. The contribution of funds should not be a measure of success because contributing money does not, in and of itself, assure the protection, maintenance, restoration or enhancement of ecosystems, natural communities or habitat types required to support the survival and recovery of the pueo. However, given that (i) the pooling of monetary resources to fund larger management projects or resolve larger research questions targeted at the recovery of pueo on Oahu is determined to be the most effective means of protecting the pueo and promoting its survival and recovery, (ii) that the control and use of the Endangered Species Trust Fund rests with DOFAW and not NPM, the contribution of funds by NPM is the most practicable measure of success in this instance. FOF 146-151.

9.f. **\`Ope\`ape\`a**. The HCP identifies the completion of tasks, such as, but not limited to, having an approved research plan, timely funding the Poamoho Ridge habitat improvement plan, and having conducted acoustic bat monitoring. The HCP also lists monitoring of efforts in removal of pigs and goats and invasive plants. The HCP is silent as to what happens in the event that pigs, goats and invasive plants are not removed to the extent and in the timeframe provided in the management plan. FOF 227. Moreover, the HCP is silent on adaptive management strategies in the event future research reveals that the mitigation plan will not benefit `ope`ape`a. FOF 216. The HCP fails to include meaningful measures of success with respect to `ope`ape`a mitigation, and in this respect is not compliant with HRS § 195D-21(b)(2)(G).

10. The HCP's adaptive management strategy focuses on avoidance and minimization measures and NPM's ability to comply with authorized take levels and mitigation requirements. It fails to provide an enforceable adaptive management strategy for revising mitigation measures when new information supports alternative mitigation measures. FOF 228-238. This failure renders the HCP non-compliant with HRS § 195D-21(b)(2)H).

11. In three instances, Applicant failed to use the best scientific and reliable data in assessing impacts and mitigation as required under HRS § 195D-21(c): (i) electing to use LWSC cut-in speed of 5 m/s, instead of 6.5 m/s; (ii) concluding that the height of WTGs has no impact on take of `ope`ape`a; and (iii) by relying solely on data from the Kahuku Wind Project for estimating the Project's take of `ope`ape`a.

12. Because of the less than robust analysis of anticipated take of `ope`ape`a by the Project, combined with the limited information available about `ope`ape`a populations on Oahu and statewide, it cannot be determined with confidence whether the Project will jeopardize the continued existence of `ope`ape`a. HRS § 195D-21(c)(1). FOF 194.

13. The Project and implementation of the HCP is not likely to cause any native species to become listed as threatened or endangered. FOF 43. HRS § 195D-21(c)(2).

14. The HCP, by (i) relying solely on data from the Kahuku Wind Project excluding data from other wind projects in the State, and (ii) failing to analyze the impact of the increased height of WTGs on `ope`ape`a, failed to provide sufficient information for the Board to ascertain with reasonable certainty the effect of the plan on `ope`ape`a in the plan area and throughout its habitat range. HRS § 195D-21(c). FOF 194.

15. The notifications provided in the OEQC Bulletin met the requirements of HRS § 195D-21(a). FOF 5-7.

16. The HCP was developed after consultation with the ESRC. HRS § 195D-4(g). FOF 10.

17. Construction and operation of the Project is a lawful activity. The take authorized by the ITL is incidental to the construction and operation of the Project and in accordance with HRS § 195D-4(g). FOF 40.

18. HRS § 1954(g)(1) requires the applicant to minimize and mitigate the impacts of the take to the maximum extent practicable. Increasing cut-in speed to 6.5 m/s, rather than 5 m/s, would minimize impacts to the maximum extent. However, the HCP provides for cut-in speed at 5 m/s and Applicant did not provide evidence that increasing cut-in speed to 6.5 m/s is not practicable. Therefore, the HCP does not satisfy HRS § 195D-4(g)(1). FOF 208-210.

19. To comply with HRS § 195D-4(g)(2), when the ITL is issued, NPM will provide a funding guarantee tool, e.g., an irrevocable letter of credit, as determined by the Board. FOF 239.

20. In accordance with HRS § 195D-4(g)(3), the Project's operational funds will be deposited in the endangered species trust fund created by HRS § 195D-3 to ensure adequate

monitoring and to ensure that Applicant takes all actions necessary to minimize and mitigate the impacts of the take. FOF 239.

21. The minimization and mitigation measures proposed in the HCP are aimed at increasing the likelihood of survival and recovery of all of the Covered Species except `ope`ape`a. HRS § 195D-4(g)(4). See COL 5.a. through 5.e., above. Additionally, not enough information is known about the potential acquisition of property for protection of `ope`ape`a habitat for the Board to analyze whether it would mitigate the impacts of take. FOF 226.

22. Because Applicant conducted a less than robust analysis of anticipated take of `ope`ape`a, especially given the higher than anticipated rate of take experienced at other wind energy projects in the state, the Board is unable to adequately assess the cumulative impact of the take of `ope`ape`a as required by HRS § 195D-4(g)(5). FOF 194.

23. To assure that the measures required under HRS § 195D-21(b) will be met, the Project's operational funds will be deposited in the endangered species trust fund created by HRS § 195D-3 to ensure adequate monitoring and to ensure that Applicant takes all actions necessary to minimize and mitigate the impacts of the take. Additionally, NPM will provide a funding guarantee tool, e.g., an irrevocable letter of credit, as determined by the Board. FOF 239. HRS § 195D-4(g)(6).

24. The Project does not involve the use of submerged lands, mining or blasting. FOF 31. HRS § 195D-4(g)(7).

25. Overall, the mitigation measures required under the HCP will provide net environmental benefits. HRS § 195D-4(g)(8). See COL 1.a through 1.e. Even though the benefit to `ope`ape`a may be uncertain, the Poamoho Ridge habitat improvement plan will provide a net environmental benefit to other native species.

26. The Project is unlikely to cause the loss of genetic representation of an affected population of any endangered, threatened, proposed or candidate plant species as there no listed threatened or endangered plant species were identified in the Project area. FOF 43. HRS § 195D-4(g)(9).

27. The required public hearing was held on the draft HCP on June 4, 2015. Additionally, the public had the opportunity to attend ESRC meetings during which the draft HCP was discussed. Although the height of the WTGs was changed subsequent to the June 4, 2015 public hearing, and there was no active discussion about the change in WTG height at the ESRC meetings, HRS 195D-4(g) does not require that additional public hearings be held after changes are made to the draft HCP. FOF 8-10.

III. RECOMMENDED DECISION AND ORDER

Based on the foregoing FOF and COL, the Hearing Officer recommends that the Board find that the HCP fails to meet all the criteria for acceptance pursuant to HRS Chapter 195D, and therefore, DISAPPROVE the HCP.

Respectfully submitted, October 31, 2017,

YVONNE Y. IZU
Hearing Officer

Testimony to Endangered Species Recovery Committee
September 30, 2020 Meeting
Agenda Item # 4

Aloha Endangered Species Recovery Committee Chair and Members,

We are providing public comments on the first sections of the Draft Hawaiian Hoary Bat Guidance Document.

Attentive Ka'u community members first became concerned when the Pakini Nui Wind Farm HCP/ITL mitigation measures, as approved by FWS, lacked ANY "research" component and just relied has the heavy reforestation of Volcanoes National Park lands (a redundant project as the HVNP already funds tree planting and regularly recruits volunteers from the local community for planting projects), with absolutely no bat research at all. The HCP did not contribute in any manner to understanding the Ka'u Hawaiian hoary bat population status and the bat's specific habitat requirements.

We share the wind farms' concerns that since the updated Guidance Document "assumes that it is not possible to produce any additional bats through mitigation, this standard is impossible to satisfy." Thus, we ask – since Pakini Nui cannot produce a single new bat for each bat killed, how can planting expensive trees help mitigate this continuous loss of bats?

We also agree that planting trees (which HVNP would be planting anyway) "unduly precludes other more effective, available and feasible mitigation measures," providing "zero incentive" for wind farm businesses to spend money on bat research which would guide actually efficacious mitigation in the future.

Finally, our recommendation for mitigation measures includes working with the local Ka'u community to identify other means of bat loss which could provide an explanation for what is really causing the dramatic decline in the Ka'u bat population for the past 40 years.

Thank you for the Committee's continuing efforts to update the Guidance Document!

Friends of the Ka'u Bats
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Technical Report HCSU-093

HAWAIIAN HOARY BAT (*LASIURUS CINEREUS SEMOTUS*) BEHAVIOR AT WIND TURBINES ON MAUI

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ABSTRACT

This study examined the activity of the endemic Hawaiian hoary bat (*Lasiurus cinereus semotus*) at wind turbines operated by Auwahi Wind Energy, LLC, on southern Maui Island, from August to November 2018. The research was conducted to assess the potential effect of wind speed and turbine operation on bat presence and behavior and compared information obtained from both acoustic monitoring and thermal videography.

During the four months of nightly surveillance at four wind turbines, we observed 384 visual (videographic) and 244 acoustic detection events involving bats. Bats were infrequently detected, averaging 0.08 events per hour for both visual and acoustic samples. Detections occurred throughout the monitoring period, but bat presence was only evident for a fraction (acoustic: 30%; visual: 44%) of the turbine-nights sampled. Bats were present throughout the night, but detections exhibited a unimodal peak centered on the first third of the night, with events largely absent in the latter half of the night and no apparent seasonal trend towards earlier or later occurrence within nights. However, a decline in the visual detection rate was noted over the four-month period (a similar assessment was not available from acoustic samples due to missing data for much of the later months). Visual bat detections were not significantly correlated over nights (i.e., temporally), but were positively associated among turbines (i.e., spatially).

Visual detections were generally brief (median = 9.0 sec), infrequent (median time between events = 49.0 min), and involved single passes (57%) largely comprised of a single bat (94%). The amount of time during which bats were visually observed amounted to only 0.05% of total videographic monitoring (2.5 hours of 5,066 total hours). Although not directly comparable to the video results because of differences in the volume of airspace sampled and nature of observation, acoustic detection events were similarly brief (median = 6.0 sec), infrequent (median time between passes = 38.8 min), and also composed only 0.05% of the total period of acoustic monitoring (1.6 hours of 3,036 total hours). Most visual observations (61%) were of individuals flying at some point during the event to within about 15 m of the turbine nacelle (machinery housing atop the monopole). Erratic flight paths were the most prevalent flight type with bats often repeatedly approaching and circling the nacelle. Terminal-phase ("feeding buzz") calls were only noted in 3% of all acoustic events.

Bats were most frequently detected visually at relatively low wind speeds (median = 3.4 m/sec); however, 10% of events occurred at wind speeds over 8.5 m/sec. Nightly bat detection rates for the four-month period of monitoring were negatively correlated with total daily precipitation. Generalized linear mixed model analysis confirmed that detection rates were negatively associated with wind speed and precipitation and indicated a positive relation with intermittent wind speed and its consequent effect on turbine blade rotation (i.e., frequent intervals of starting and stopping).

The co-occurrence of bat detection obtained from videographic and acoustic monitoring methods was generally low, and in instances when individuals were visually observed, bats were detected acoustically during only 12% (within a 10-minute window), 22% (within a 2-hour window), and 56% (at some point during the entire night) of such events. Most visual detections (65% within a 2-hour window) lacking an acoustic detection involved bats observed flying within about 15 m of the turbine nacelle on which acoustic detector microphones were situated.

INTRODUCTION

The prevalence and causes of bird collisions with wind turbines have been studied and documented since the 1980s (e.g., Byrne 1983, Howell and Didonato 1991). Investigation into the scope of bat fatalities at wind energy facilities is a more recent development (e.g., Fiedler 2004, Johnson 2005, Kunz *et al.* 2007, Arnett *et al.* 2008). These studies have generally monitored bat acoustic activity at turbines to provide insight into the association of bat occurrence, turbine operation, and geographic and weather variables (e.g., Baerwald and Barclay 2009, Weller and Baldwin 2012, Foo *et al.* 2017).

Bats, however, are cryptic nocturnal mammals that can be difficult to sample during flight and at relevant heights. Recent research has found bats in flight may often forgo echolocation or vocalize in a way that is not detectable with common acoustic monitoring methods (Gorresen *et al.* 2017, Corcoran and Weller 2018). Silent flight behavior has implications for studies of bat behavior and management aimed at minimizing or avoiding fatalities associated with wind energy.

As an alternative to acoustic sampling, visual-based methods such as thermal imaging offer certain advantages due to its capacity to sample relatively large volumes of airspace over long periods and reveal aspects of bat behavior not readily obtained solely from acoustic data. To date, however, only a small number of studies have used thermal imaging to conduct long-term monitoring of bat behavior at wind turbines. These studies have shown bats engaged in investigative behavior of turbine blades, nacelles (machinery housing atop the monopole), and monopoles; repeated approaches after near strikes with moving blades; social interactions by multiple bats; and a concentration of flight activity on the leeward (downwind) side of turbines (Horn *et al.* 2008, Cryan *et al.* 2014, Gorresen *et al.* 2015b). Visual-based systems can produce higher detection probabilities than acoustic-only sampling (Gorresen *et al.* 2018) with the potential to improve assessments of bat activity and behavior at turbines (e.g., Korner-Nievergelt *et al.* 2013). However, although not relevant to Hawai'i (which harbors a single species of bat), video recordings are generally not informative for species identification.

Monitoring that combines both acoustic and visual-based systems may also have additional benefits in linking specific behaviors generally only evident when analyzed as paired data sources (e.g., response to deterrents [Gorresen *et al.* 2015a]; flight and vocalization indicative of foraging [Gorresen *et al.* 2018]; obstacle avoidance [Corcoran and Weller 2018]). Sampling with combined acoustic-visual systems may also help address questions related to the frequency of bat vocalization at turbines, a key consideration for management aimed at minimizing collision risk by curtailing turbine operation following the detection of vocalization (e.g., Hayes *et al.* 2019).

In light of the above, we initiated a study with support of Auwahi Wind Energy, LLC, that applied both acoustic and visual-based monitoring systems with the objective of examining bat behavior at wind turbines and its relation with wind speed, a principal variable in determining bat activity and collision risk at turbines (Korner-Nievergelt *et al.* 2013, Wellig *et al.* 2018). The Hawaiian hoary bat (*Lasiurus cinereus semotus*, Vespertilionidae) served as the focal species in this study because it is an endangered endemic susceptible to fatality by collision with moving wind turbine blades (Gorresen *et al.* 2015b) and the subject of management aimed at mitigating these effects (Mykleseth 2017, Tetra Tech 2018). The North American subspecies, *L. c. cinereus*, accounts for approximately 40% of all bat fatalities at turbines in continental North

America (Arnett and Baerwald 2013). Also known as the ʻŌpeʻapeʻa, the Hawaiian hoary bat is the only extant native terrestrial mammal and sole bat species in Hawaii State and occurs on all of the major islands (Tomich 1986). Given previous observations of cryptic vocalization by Hawaiian hoary bats in semi-natural environments (Gorresen *et al.* 2017), we also examined the correspondence between acoustic and visual-based detection rates of bats at wind turbines.

METHODS

Study Area

The study area was located on the wind energy facility operated by Auwahi Wind Energy, LLC, on southern Maui Island, Hawaii. Wind turbines at the facility consist of eight 3-megawatt WTGs (Siemens SWT-3.0-101, Hamburg, Germany), each with a hub height of 80 m, a rotor diameter of 101 m, a maximum height of 131 m, and a rotor-swept area of 8,012 m^2 (www.thewindpower.net/turbine_en_275_siemens_swt-3.0-101.php). Sampling for bat occurrence spanned a four-month period from August 1 to November 30, 2018, at four wind turbine generators (WTG 2, 4, 5, and 7) previously equipped with acoustic detectors managed by Natural Power Consultants, LLC (Saratoga Springs, New York, USA; described below).

Landcover in the area is dominated by dryland vegetation comprised of open grassland, wiliwili (*Erythrina sandwicensis*) groves, and kīawe (*Prosopis juliflora*). The moderately sloping area inclusive of the monitored turbines spans a low elevation range (150–315 m above sea level [asl]) near the coast and is situated over 7 km from tree vegetation that might serve as day-roost habitat (within the region, in areas generally >600 m asl).

Local climatic conditions in the area exhibit relatively constant temperatures, little rainfall, and persistent strong winds throughout much of the year. Sunset to sunrise (nighttime) temperature ranged from 29.1 to 25.9°C on August 1 and from 26.6 to 22.9°C on November 30 (recorded at a weather station located at sea-level 10.5 km west of the study area; www.wunderground.com/dashboard/pws/KHIKIHEI5; accessed December 3, 2018). Cumulative daily precipitation totaled 33.0 cm over the four-month study period (recorded at a weather station located 7.3 km east-northeast from the Auwahi Wind Energy facility [USGS 203721156151601 255.0 Kepuni Gulch Rain Gage; 225 m elevation] waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=203721156151601; accessed December 3, 2018; also available at https://doi.org/10.5066/F7P55KJN). Prevailing winds during this period were generally easterly, and nighttime wind speeds recorded at the nacelle (machinery housing atop the monopole) of sampled turbines averaged 7.1 m/sec (25.6 km/hr), with speeds above 13.0 m/sec recorded about 10% of the time (G. Akau, Auwahi Wind Energy, written comm., 2018). Wind speed and direction were recorded by an ultrasonic anemometer (FT702LT-V22, FT Technologies Ltd., Sunbury on Thames, United Kingdom) and adjusted for placement behind the rotors on a turbine nacelle. Wind speed data for the monitored turbines were provided by Auwahi Wind Energy.

Monitoring Bat Occurrence and Behavior

The rotor-swept area of each turbine was monitored using a surveillance camera equipped with a 19-mm lens (Axis Q1942-E, Axis Communications, Lund, Sweden) that imaged in the thermal infrared spectrum (~9,000–14,000 micrometers) of electromagnetic radiation. The camera sampled at a rate of 30 frames per second with a resolution of 640 by 480 pixels and required no supplemental illumination. The camera was mounted approximately 4 m from the ground on the turbine monopole using a mounting base (RigMount X6 Magnet Camera Mounting Platform, Rigwheels, Minneapolis, Minnesota, USA; Figure 1). The camera was aimed directly up the tower such that the video scene included the monopole, turbine blades, nacelle, and surrounding airspace. Cameras were placed on the leeward (downwind) side of the turbines to image the perspective at which bat activity has been generally shown to be highest in prior studies (Cryan *et al.* 2014, Gorresen *et al.* 2015b).

Figure 1. Placement of camera on turbine monopole (circled, left panel) and camera orientation (right panel).

Video imagery was processed using custom-written code and matrix-based statistical software (Mathworks, Natick, Massachusetts, USA) to automatically detect animals flying through the video scenes. Video was recorded at 30 frames per second, and every 10th video frame was analyzed resulting in the detection of events lasting as little as 0.3 sec. All objects detected by software algorithms were visually reviewed and identified as bat, bird, or insect. Previous field trials showed that bats were detectable with thermal videography at distances of over 100 m.

Bat vocalization was acoustically monitored from atop turbines with acoustic detector systems (Batlogger WE X2, Elekon AG, Luzern, Switzerland) installed and managed by Natural Power Consultants, LLC (Saratoga Springs, New York, USA). Each turbine had one rotor-facing (windward) and one rear-facing (leeward) omnidirectional microphone mounted atop the nacelle and were each tipped down about 9 degrees from vertical. Detectors began recording

1 hour before local sunset until 1 hour after sunrise the next morning. Acoustic detections were recorded without digital compression as full-spectrum wav sound files with the following settings: sampling rate = 312.5 kHz; trigger frequency range of 9–60 kHz within a microphone sensitivity range of 10–150 kHz; decibel gain = 12; period trigger = 95; crest factor = 5; pre- and post-trigger duration = 500–800 ms; max gap time between calls = 200 ms; maximum call file duration = 3 sec; minimum FFT value for trigger = 5; minimum sound level for trigger = 1%. Microphone sensitivity tests were automatically conducted on a daily basis, and results were provided by Natural Power Consultants, LLC. Prevailing wind direction at the facility is usually from the east (80%; G. Akau, Auwahi Wind Energy, written comm., 2018); therefore, acoustic and video observations were expected to jointly sample the same airspace for approximately the same proportion of time.

Delays with acoustic detector installation atop turbines and the progressive decay of microphone sensitivity over the monitoring period limited the number of sample nights available for analyses. Microphone sensitivity was particularly problematic for the microphone aimed towards the rotor; consequently, with the exception of one analysis, only data for the rear-oriented microphone were examined herein. The periods during which acoustic data were determined to be available totaled to 246 nights (turbine 2, August 1–November 3 [63 nights]; turbine 4, September 20–October 6 [17 nights]; turbine 5, August 8–November 30 [115 nights]; turbine 7, August 7–September 26 [51 nights]). Moreover, because microphone sensitivity decayed as a function of time since installation, examination of acoustic detections relative to time of year was not possible because these variables were largely confounded. For these reasons, most descriptive analyses and the statistical modeling of bat occurrence and behavior relative to weather and turbine operation variables focused on thermal video-based detections. The exception was use of all acoustic wav files (i.e., both rotor- and rear-oriented) in an assessment of the correspondence of acoustic and visual (video) detections (the rationale being that this would minimize underestimation of the correspondence of both types of detections). The correspondence between acoustic and visual detection events were examined at three scales: the entire night (averaging approximately 12 hours), a 2-hour period (i.e., an acoustic detection 1 hour before or after a visual detection), and a 10-minute period (i.e., an acoustic detection 5 minutes before or after a visual detection). Bat passes at any point during a visual detection were noted if they occurred at a distance of approximately 15 m or less from the turbine nacelle, a range within which the probability of acoustic detection is high, particularly for low-frequency echolocation calls (Adams *et al.* 2012, Gorresen *et al*. 2017), and used to conservatively assess the proportion of visual detections lacking a corresponding acoustic detection.

Hawaiian hoary bat vocalizations were examined using Kaleidoscope Pro software (version 5.1.9, Wildlife Acoustics, Concord, Maine, USA). All echolocation pulses, feeding buzzes, and files with multiple bats were verified by audio and visual inspection, and all noise files were visually reviewed to ensure that bat calls were not missed. Terminal-phase calls ("feeding buzzes" emitted just prior to an attempted insect catch) were qualitatively distinguished from search and approach-phase calls by a rapid increase in the call rate. Ancillary information on the frequency of acoustic detection of bats from ground-based detectors in the region are described in Pinzari *et al.* (2019a), and for which acoustic data are available at https://doi.org/10.5066/P9U0KRMY (Pinzari *et al.* 2019b).

Videographic recordings were analyzed to identify individual "detection events", defined as a single pass or two or more detections occurring less than a minute apart, such that if bats went out of video field-of-view they were not counted as independent events if they reappeared within 1 minute (consistent with previous work by Cryan *et al.* 2014 and Gorresen *et al.* 2018). Likewise, acoustic detections were also grouped as the same detection event when two or more passes occurred less than 1 minute apart. The resulting data for both video and acoustic sampling included total counts of detection events per night. In addition, to account for partially sampled nights or nights for which video was not available from one or more turbines, the nightly rate of bat detection (number of events per hour, adjusted for duration of night and sampling effort) was calculated both for individual turbines and all four turbines combined. Flight behavior was qualitatively designated as straight, curved, or erratic based on whether the flight path was linear or included one or more curves or loops during the video detection event. In cases where two or more bats were concurrently visible, behavior was recorded as agonistic when individuals flew within a few meters of each other and interacted with sharp turns and chases.

Variables Associated with Bat Detection
We examined the association of bat occurrence and behavior with several variables related to weather conditions and turbine operation. We hypothesized that nightly counts of detection events would be negatively related to wind speed and precipitation, as these conditions may restrict flight activity or foraging success (Erickson and West 2002). Conversely, we expected detections to be positively influenced by wind speed variability because high values of this variable reflect the recurrence of low wind periods during which bats may be more active or more likely to approach turbines. Moreover, the number of turbine blade rotation "start-ups" (i.e., from zero or low to high rates of rotation) has been found to be positively related to bat fatalities (Schirmacher *et al.* 2018), an outcome possibly linked to increased bat occurrence or activity at low wind speeds. The frequency of start-ups is generally associated with the incidence of wind speeds below that which triggers turbine shut-down and low-wind speed curtailment (LWSC; a management protocol for minimizing the likelihood of bat fatalities and incidental take). Consequently, high wind speed variability and frequent turbine start-ups are both variables expected to be positively related to nightly counts of detection events. Curtailment is accomplished by "feathering" turbine blades; that is, pitching blades parallel to the wind, resulting in very slow movement of the rotor and blades. During the period of study, turbine LWSC at Auwahi Wind Energy implemented a "cut-in speed" (i.e., wind speed at which the turbine begins to rotate and generate power) of 6.9 m/sec from August to October and 5 m/sec in November.

Wind speed (m/sec) recorded at the nacelle of each turbine at 10-minute intervals and limited to night-time periods were used to calculate nightly mean and standard deviation (SD) metrics; referred herein as "wind-mean" and "wind-sd". Turbine blade movement, measured as rotations per minute ("rpm"), was obtained for each turbine over 10-minute intervals from Auwahi Wind Energy. Turbine rpm during individual bat detection events were derived directly from the video recording of each event by calculating the time needed for the rotor to complete a full rotation. The frequency of turbine start-ups ("rpm-starts") was determined by tallying the number of times per night a turbine transitioned from ≤1 rpm to >1 rpm in two or more consecutive 10-minute periods. For context, at 1.0 rpm, blade tips are moving at a speed of 5.3 m/sec (= 19.0 km/hr) for a turbine rotor diameter of 101 m and a circumference of 317 m.

Precipitation was obtained from a weather station located 7.3 km east-northeast from the Auwahi Wind Energy facility (USGS site number 203721156151601, 255.0 Kepuni Gulch Rain Gage). Temperature was not included in analyses due to the low variability observed in nighttime values over the four months of sampling (sunset to sunrise temperature differences averaged about 3.5°C).

Descriptive Analyses and Statistical Modeling

Bat occurrence and behavior were explored and graphically described with a variety of methods (e.g., analysis of variance, simple linear regression, correlation analysis) in the statistical computing environment R (version 3.5.1; R Core Team 2018). The relation of nightly counts of bat detection events to multiple predictor variables were also examined with generalized linear mixed models (GLMMs) using the glmmTMB package (Brooks *et al.* 2019) to account for temporally and spatially correlated observations requiring the incorporation of random effects. In the GLMMs the variables "night" and "turbine" were added as random effect terms to deal with repeated measures at the four turbines. In addition, the models were fit to counts for the following fixed effects: "rpm", "rpm-starts", "precip", "wind-mean", and "wind-sd". The fixed effect terms were scaled and centered on zero (creating z-scores) using the base scale function in R to improve model convergence and allow for direct comparison of the magnitude of fixed effect coefficients. Mean wind speed and turbine rpm were highly correlated ($r = 0.70$ from measures for all four turbines, and $r = 0.92$ when excluding turbine 2, which was not operational for most of the monitoring period). In addition, rpm start-ups and the standard deviation of wind during the night were also moderately correlated ($r = 0.37$). All other variables were correlated pairwise at an $r \leq 0.35$. Therefore, to minimize multicollinearity in regression analyses and limit the number of models tested, models were developed that did not jointly include both of the correlated variables. To account for differences in nightly sampling duration among turbines, we included the log of the total duration of recording per night and turbine as an offset in models, thereby converting counts of detection events to a detection rate.

Preliminary regression analyses demonstrated underdispersion of the residuals in both negative binomial and Poisson models. The consequence of underdispersion is that standard errors (SEs) are generally too conservative (i.e., confidence intervals tend to be too broad and p-values too large) potentially resulting in false-negative conclusions about parameter effects (Brooks *et al.* 2019). To address this, we fit GLMMs with several additional distribution specifications that allow for underdispersion; specifically, generalized Poisson and Conway-Maxwell-Poisson (Brooks *et al.* 2019). The four distribution groups are referred herein as NB, P, GP, and CMP for the negative binomial, Poisson, generalized Poisson, and Conway-Maxwell-Poisson models.

The candidate set of predictor variables totaled to 18 models, including a null model with only the random effect terms "night" and "turbine", the offset, and no fixed effects. We used small-sample-size corrected Akaike information criterion (AICc) via the AICctab function from the bbmle package (Burnham and Anderson 2002, Bolker and R Core Team 2017) to compare all models. Model ranking was performed in two steps: the first identified the top-ranked model from among the 18 candidate models within each of the four distribution groups (NB, P, GP, and CMP), and the second step ranked this subset. Final top-ranked models (i.e., those with a ΔAICc < 7; Burnham *et al.* 2011) were examined with post-fitting diagnostics performed with the DHARMa package (Hartig 2017). A statistical significance criterion of $P < 0.05$ was used in all tests.

Results

Visual (Thermal Video) Bat Detections—Descriptive Analyses

Thermal video was recorded at four turbines over the four-month period between August 1 and November 30, 2018. Technical difficulties resulted in the loss of recording for 65 turbine-nights. The number of nightly recordings over the 122-night period was 111, 119, 107, and 75 for turbines 2, 4, 5, and 7, respectively, for a total of 412 turbine-nights with a full or partial night of recording (median duration = 12.6 hours, including a 15-minute period before sunset and after sunrise). This yielded 5,066 hours of video that resulted in a total of 384 detection events of bats (72%) and bat-like observations (27%; n = 140) with an additional 288 bird observations. Only definitive bat detections were used in analyses of occurrence and behavior (i.e., bat-like detections were not included as these were generally brief and/or of distant targets). Visual bat detection data are available at https://doi.org/10.5066/P937H9LQ (Gorresen 2020) and are summarized in Appendix I and II.

Bats were detected visually in 44% (n = 180) of the turbine-nights sampled. Detections at turbines occurred throughout the night, with the earliest occurring 8 minutes after sunset and the latest 16 minutes before sunrise. Detections exhibited a unimodal distribution and a median of 0.27 for the fraction of night at which the observation occurred, corresponding to a peak of 3.4 hours after sunset (Q1 = 0.18, Q3 = 0.45, mean = 0.33 ± 0.20 SD; standardized as a fraction of night and scaled from 0 at sunset to 1 at sunrise; Figure 2). Detections generally did not begin until about an hour after sunset.

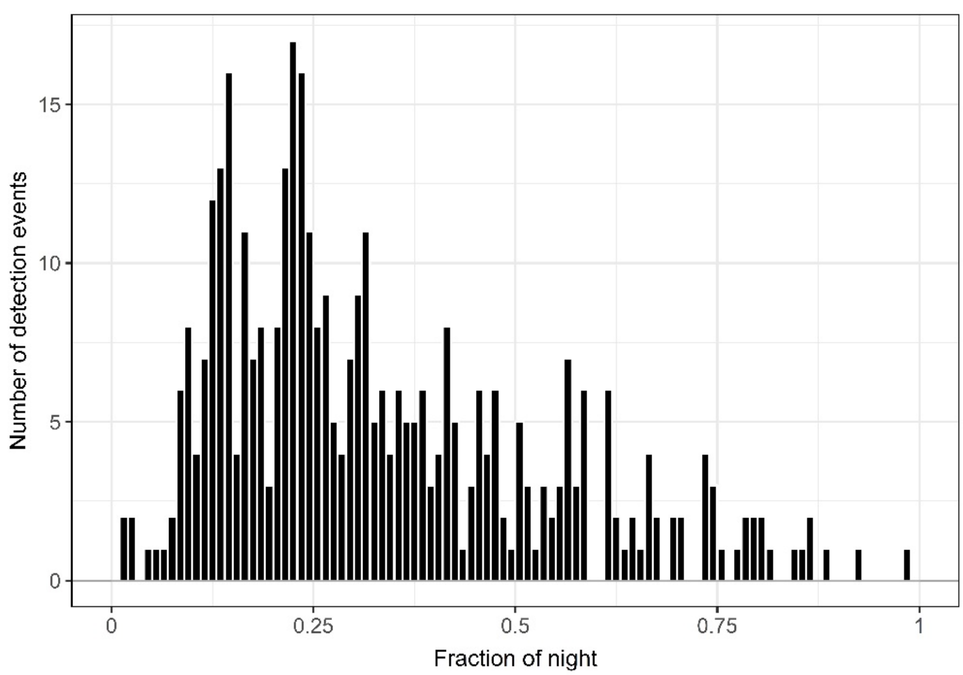

Figure 2. Distribution of visual detections of bats by time of night. To account for seasonal changes in night duration, the time of detection was standardized as a fraction of night and scaled from 0 (sunset) to 1 (sunrise).

Bats were detected throughout the four-month monitoring period (Figure 3), and linear regression demonstrated no evidence of a seasonal shift toward earlier or later activity during the night (slope = -1.17e-09, SE = 3.42e-09, *P* = 0.733). However, the rate of nightly bat detection (number of events per hour; adjusted for duration of night and sampling effort, including partially sampled nights) was highly variable among nights but evinced a seasonal pattern, with the rate decreasing (slope = -0.0005, SE = 0.0002, *P* = 0.029) from a mean of 0.11 events/hour (SE = 0.02) on survey night 1 (August 1) to 0.05 events/hour (SE = 0.02) on survey night 122 (November 30; Figure 4).

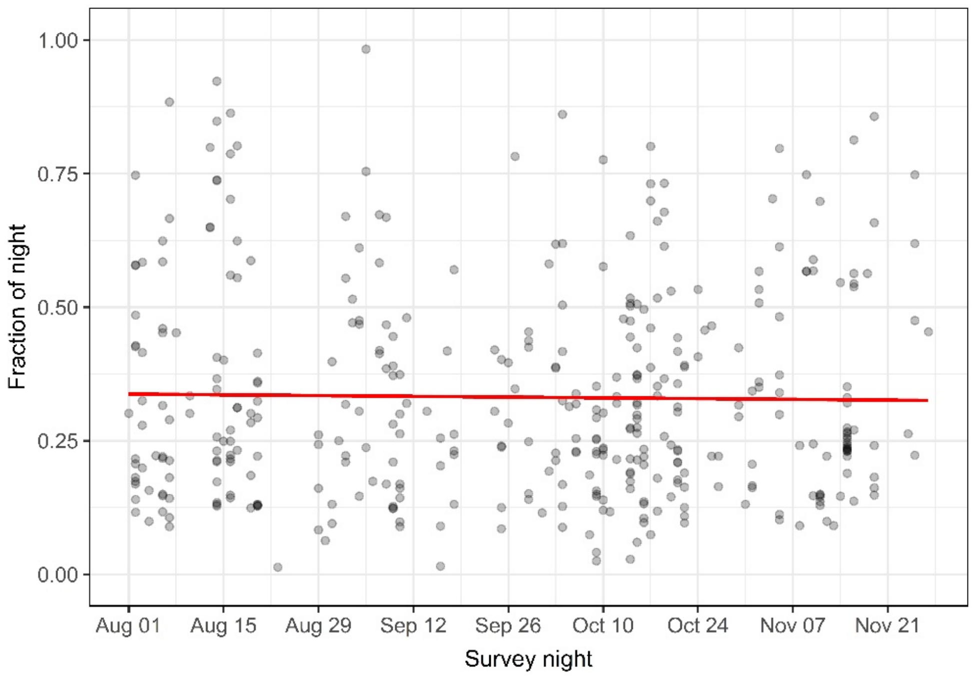

Figure 3. Detections (points) of bats by time of night over the four-month videographic monitoring period. To account for seasonal changes in night duration, the time of detection was standardized as a fraction of night and scaled from 0 (sunset) to 1 (sunrise). Situated below 0.5, the trendline of the mean values (red line) indicates a greater proportion of detections occurred in the first half of the night throughout the monitoring period.

The overall mean nightly detection rate for the entire videographic monitoring period was 0.08 events/hour (SD = 0.10, Q1 = 0.00, median = 0.04, Q3 = 0.13). Bat detection rates for each turbine were similar to the overall mean (Table 1, Figure 5) and not found to be significantly different from one another (F[3, 402] = 0.885, *P* = 0.449). Nightly detection rates demonstrated a weak but significant spatial correlation among turbines (all p-values <0.001), with pairwise Kendall's tau values ranging from 0.23 to 0.31 (Figure 6). The detection rate for all turbines combined demonstrated a weak positive relation with the rate on a previous night (r = 0.18), but the temporal pattern was not statistically significant to a lag of up to 12 nights (all p-values ≥ 0.05; Figure 7).

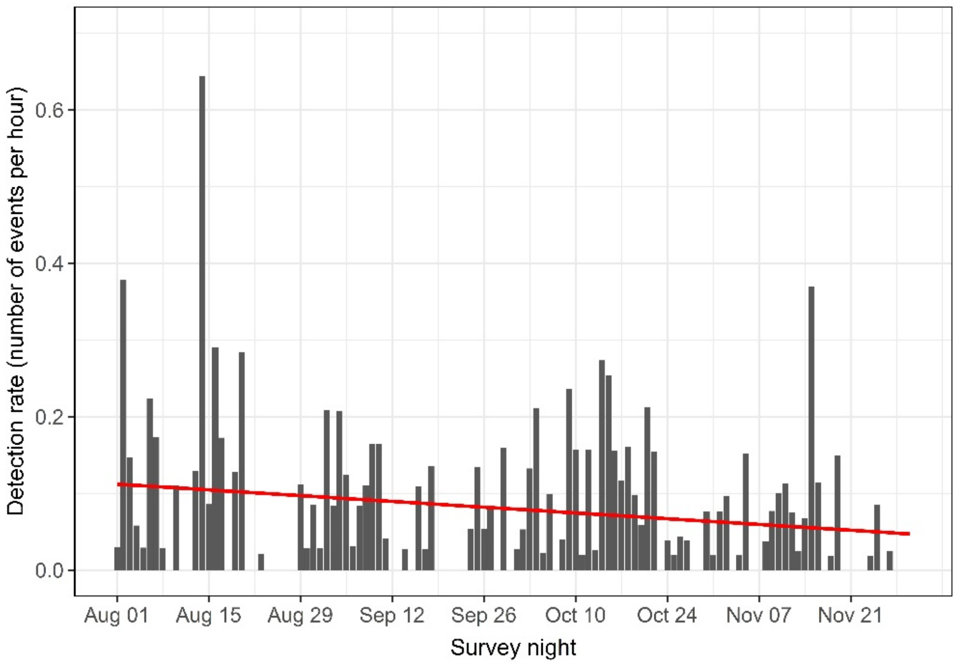

Figure 4. Detection rate of bats (number of events per hour per night) for all four turbines combined over the four-month videographic monitoring period. Detection rate is adjusted by survey effort (i.e., sample duration night interval and number of turbines monitored per night). The red line is a linear model of trend in detection rate over the monitoring period.

Table 1. Overall mean detection rate of bats by turbine (mean and SD). Detection rate was calculated as the nightly total of detection events at a turbine divided by the sample duration per night at the turbine. The combined mean is the overall average of the nightly detection rates for the four turbines over the four-month videographic monitoring period.

Turbine	Nightly mean (events/hour)	SD
2	0.07	0.10
4	0.07	0.13
5	0.09	0.14
7	0.07	0.11
combined mean	0.08	0.12

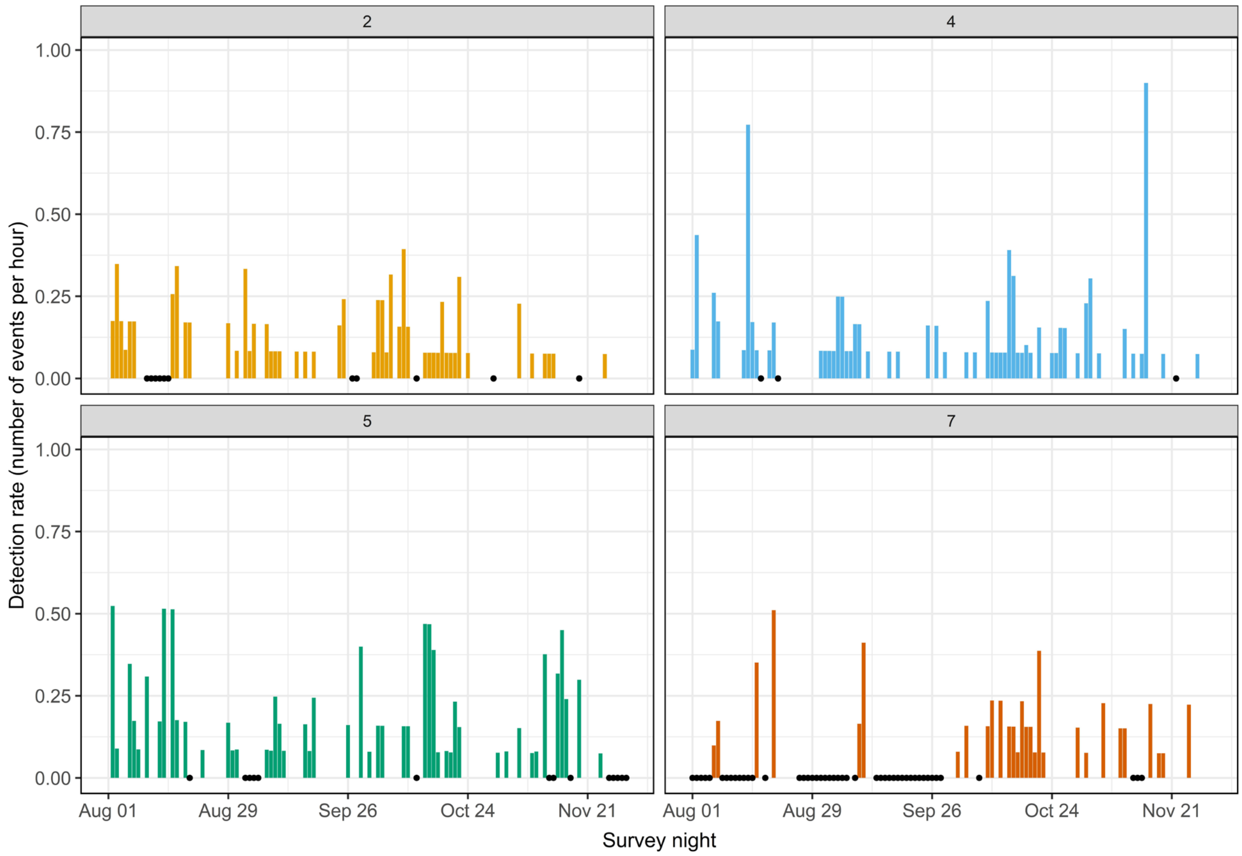

Figure 5. Detection rate of bats (number of events per hour per night) for each of four turbines (2, 4, 5, and 7) over the four-month videographic monitoring period. Detection rates are adjusted by survey effort (i.e., sample duration within night interval). Nights with no samples are indicated with a black point.

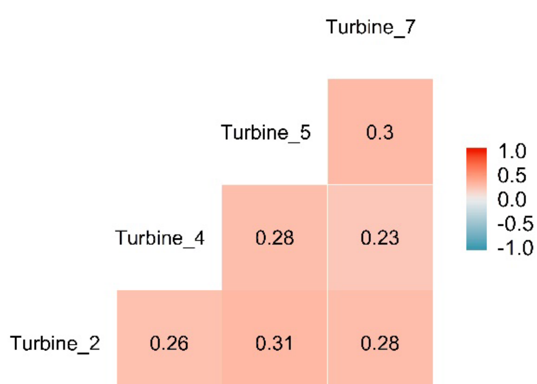

Figure 6. Spatial pairwise correlation of nightly detection rates between turbines. The p-values for all Kendall's rank correlation tau values are <0.001.

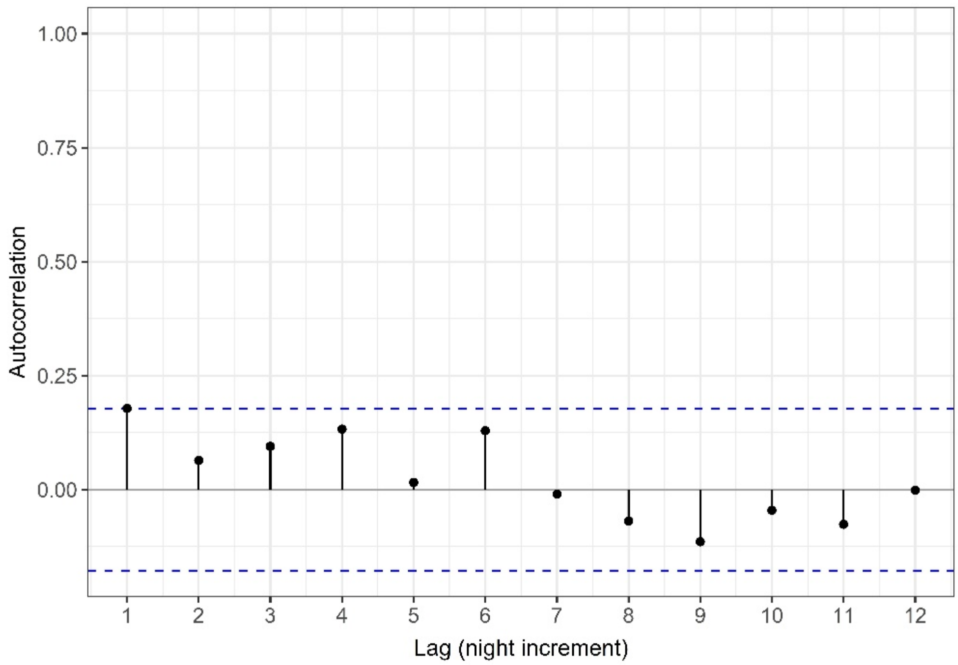

Figure 7. Temporal autocorrelation in the detection rate of bats (number of events per hour per night) for a series of lag increments up to 12 nights for all turbines combined over the four-month videographic monitoring period. Dashed lines indicate the threshold for statistical significance given sample size.

Almost all (n = 362; 94%) bat detections involved single bats within the 1-minute period used to quantify each event. Multiple bats seen concurrently were observed infrequently, with two bats (n = 22) observed during 6% of detection events, and no greater number noted at any time with any certainty. Most (n = 14) observations of two bats involved individuals not directly interacting, and bats were only rarely seen chasing (n = 5) or closely following each other (n = 3). All observations of bats engaged in chasing occurred when the individuals were in proximity (approx. <15 m) to the turbine nacelle.

The duration of individual bat detection events (in part determined by the limited field-of-view) averaged 23.5 sec per event. However, 11% (n = 41) of the events lasted 60 sec or more, with 4% (n = 14) of events lasting ≥120 sec, and one event was sustained for at least 211 sec (min = 0.5, Q1 = 3.8, median = 9.0, Q3 = 28.3, max = 211.2). On a per-turbine basis, the cumulative duration of nightly detection events averaged 50.1 sec (min = 0.6, Q1 = 7.1, median = 20.9, Q3 = 56.9, max = 804.2; Figure 8), with the maximum duration (totaling 13.4 minutes) comprised of a series of 12 distinct events (occurring on November 15 at turbine 4). The duration of detection events appears to moderately decline over time; however, linear regression demonstrated no evidence of a seasonal shift toward shorter or longer duration episodes of bat activity (slope = -0.016, SE = 0.012, $P = 0.187$) during the four-month period of monitoring (Figure 9). Although the individual and cumulative duration of detection events on some nights sometimes lasted several minutes, bats generally did not appear to be spending much time in the rotor-swept zone imaged by video. The duration of all detection events totaled to 150 minutes (9,015 sec) and made up only 0.05% of the total period of videographic

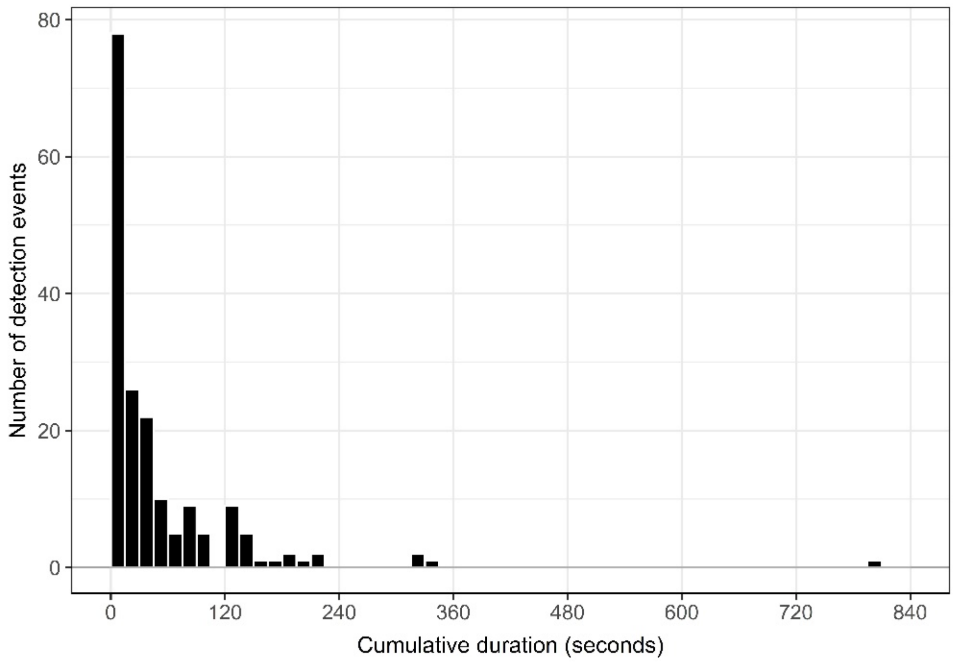

Figure 8. Distribution of the cumulative duration (seconds) of detection events on a nightly and per-turbine basis over the four-month monitoring period.

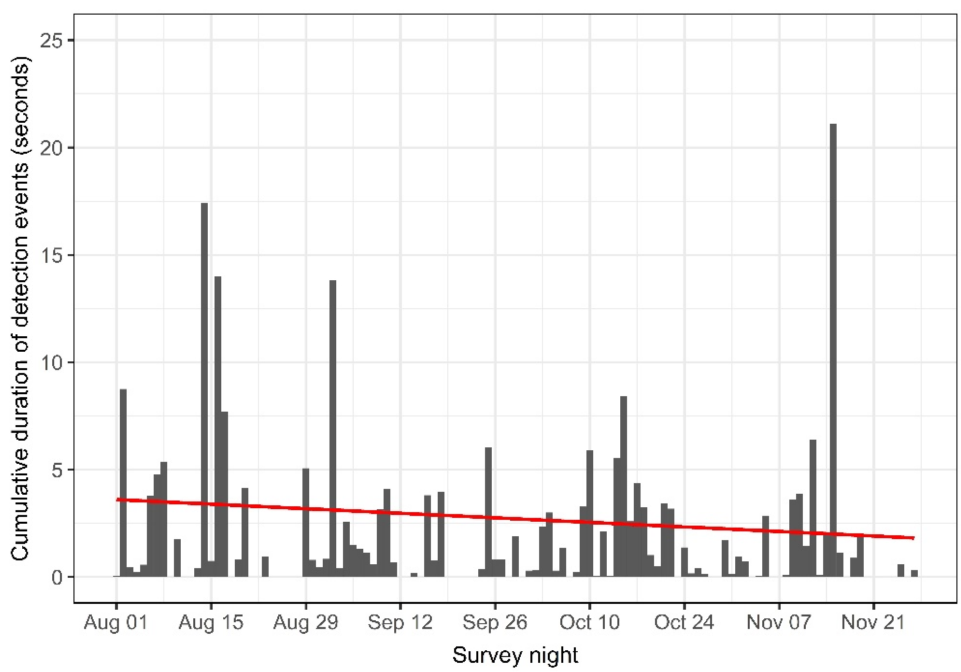

Figure 9. Cumulative duration (seconds) of detection events of bats on a nightly and per-turbine basis over the four-month monitoring period. The red line is a linear model of trend in event duration over the monitoring period.

monitoring (2.5 hours of 5,066 total hours). The time difference between consecutive detection events within a night averaged 80.4 minutes (min = 1.1, Q1 = 12.8, median = 49.0, Q3 = 101.2, max = 481.5; Figure 10). Most detection events consisted of a bat making a single pass through the field of view (57%; n = 220). Repeated passes (which together compose individual detection events when occurring <1 minute apart) were seen less frequently (2–4 passes [34%; n = 122], 5–10 passes [10%; n = 38], and 11–15 passes [1%; n = 4]).

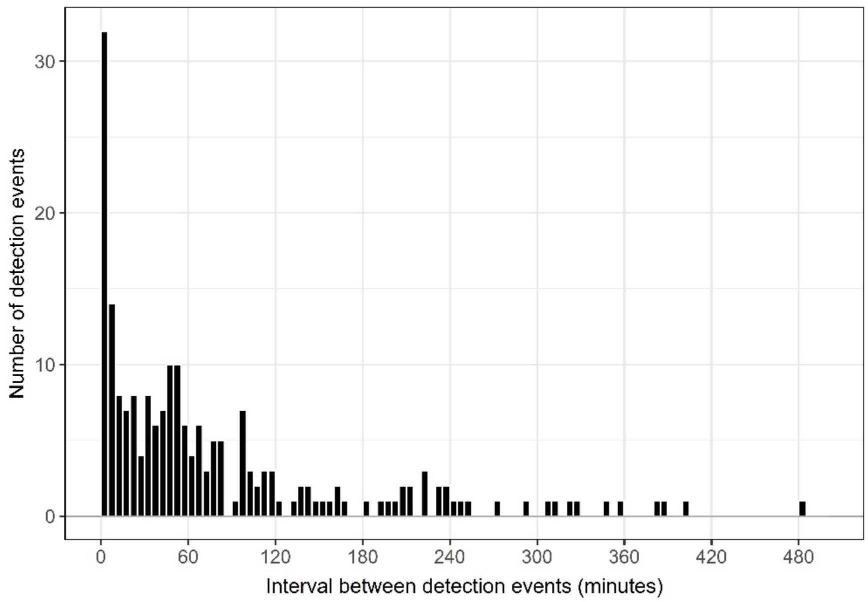

Figure 10. Distribution of the time interval (minutes) between consecutive detections of bats within a night combined for all turbines over the four-month monitoring period.

The largest proportion of bat detections involved erratic flight (80%; n = 306) suggestive of active foraging behavior in the immediate area of the turbine (i.e., within the video field-of-view; Table 2; Figure 11). Curved flight trajectories that may have involved either an approach towards or avoidance of the turbine were seen in 14% (n = 55) of events. Observations of straight flight paths indicative of a "fly-by" and little time spent near a turbine were observed in 6% (n = 23) of detections. Some of the observed curved and straight trajectories may simply consist of the less erratic parts of flight by bats otherwise engaged in foraging.

Table 2. Number and proportion of detection events by flight path type relative to bat proximity to nacelle (near = <15 m, far = ≥15 m).

Flight type	Near	Far
straight	13 (3%)	10 (3%)
curved	30 (8%)	25 (7%)
erratic	190 (49%)	116 (30%)
Total	233 (61%)	151 (39%)

Figure 11. Thermal video frame of a Hawaiian hoary bat at nacelle height (80 m) and within approximately 15 m of the nacelle (green dashed line), a distance within which vocalizing bats are likely to be recorded by acoustic detectors.

Most bat detection events (61%; n = 233) involved individuals that flew to within an estimated 15 m of the turbine nacelle. Comparatively, this 15-m radius area around the nacelle composed about a third of the video camera field-of-view; therefore, bats detected on video seemed to have closely approached the nacelle and upper monopole more often than not. Erratic flight paths were the most prevalent flight type observed, with bats repeatedly approaching and circling the nacelle in most cases. However, a Fisher's exact test did not demonstrate a significant relation ($P = 0.513$) between the number of events by flight path type as a function of bat proximity to turbine nacelle. Observations of displacement of bats or near-strikes by spinning turbine blades were seen in only two instances (0.5%). Direct strikes of bats by turbine blades were not observed.

Bats were most frequently detected at relatively low wind speeds (as measured at the turbine nacelle at 10-minute intervals; Figure 12). Wind speeds up to 3.4, 5.4, and 8.5 m/sec corresponded to 50%, 70%, and 90% of cumulative bat detection events, respectively, and

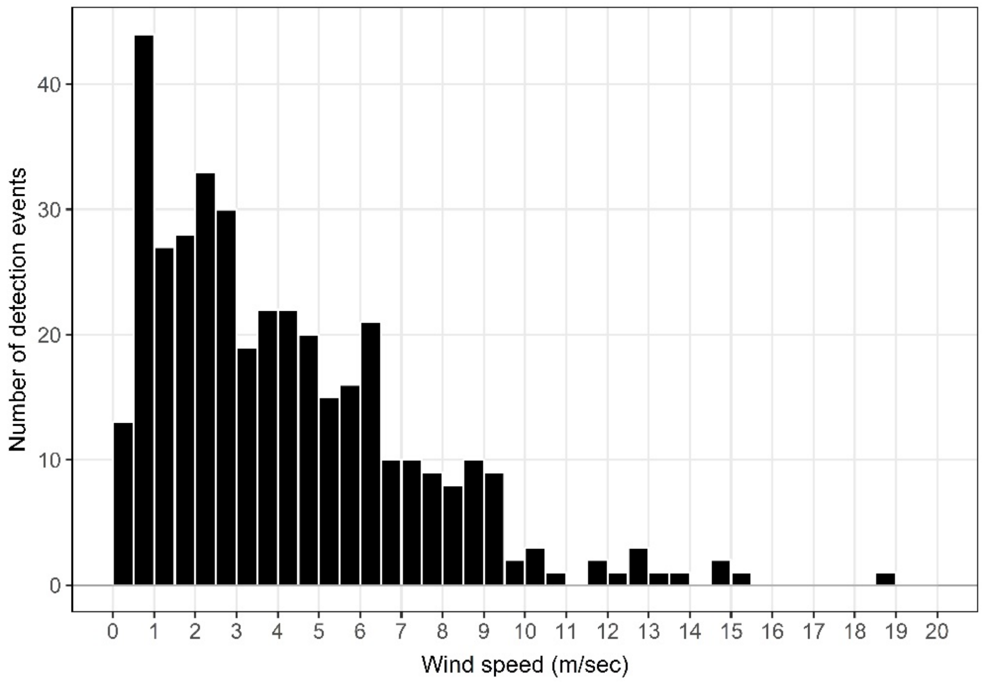

Figure 12. Distribution of bat detection events relative to wind speed (m/sec) measured at the turbine nacelle at 10-minute intervals over the four-month monitoring period.

10% of total detection events occurred at wind speeds between 8.5 m/sec and the maximum observed value of 18.9 m/sec (Table 3). A two-sample Kolmogorov–Smirnov (KS) test comparing wind speed during bat detection events to "ambient" nighttime conditions (both recorded at turbine nacelles) confirmed that the cumulative distributions were significantly different (KS test statistic D = 0.352, $P < 0.0001$; Figure 13). The KS test statistic D, defined as the maximum value of the absolute difference between the two cumulative distribution functions, was located at a wind speed value of 6.6 m/sec, corresponding to approximately 81% of cumulative bat detection events.

Table 3. Distribution of wind speed (m/sec) during bat detection events relative to randomly selected "ambient" nighttime conditions.

Samples	Mean	Median	70%	75%	80%	85%	90%	95%	100%
bat detection events	4.1	3.4	5.4	6.0	6.4	7.4	8.5	9.4	18.9
ambient nighttime	7.1	7.0	9.8	10.5	11.1	12.2	13.0	14.8	22.0

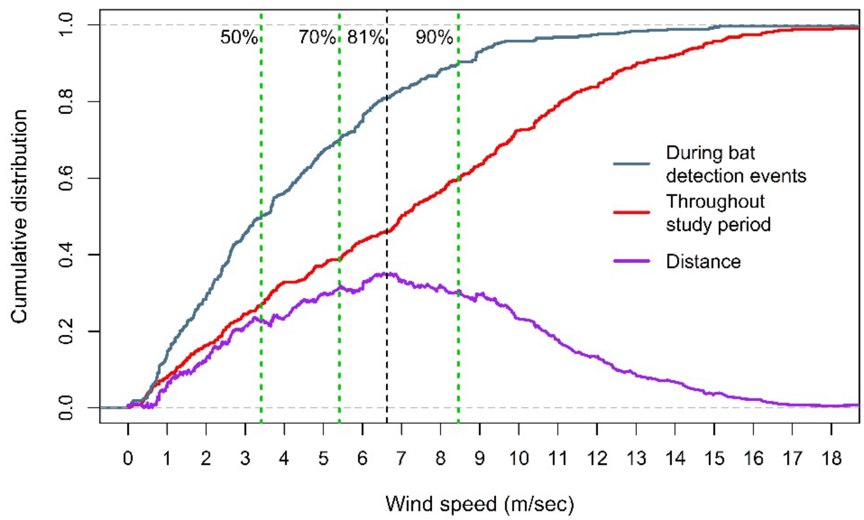

Figure 13. Cumulative distribution of wind speed (m/sec) during bat detection events relative to randomly selected "ambient" nighttime conditions recorded throughout the four-month monitoring period. A two-sample Kolmogorov–Smirnov (KS) test confirmed that the cumulative distributions were significantly different (KS test statistic D = 0.352, $P < 0.0001$). The KS test statistic D, defined as the maximum value of the absolute difference between the two cumulative distributions ("distance"), was located at a wind speed value of 6.6 m/sec, corresponding to approximately 81% of cumulative bat detection events (vertical dashed black line). Wind speeds for a range of cumulative distribution intervals (50%, 70%, and 90%) are shown with vertical dashed green lines.

There were relatively few bat detection events during periods when the turbine blades were in motion (Table 4, Figure 14). Bat observations during which there was no turbine rotation composed 81.5% (n = 313) of total events. A further 10.2% (n = 39) of events were observed at turbine rotor speeds of 0.1 to 0.5 rpm, with the remaining 8.3% (n = 32) at rpm values >0.5. However, of the 32 events that occurred when the turbine was moving >0.5 rpm, 8 events ensued when wind speeds were below the curtailment "cut-in" threshold (i.e., the wind speed at which the turbine begins to rotate and generate power; ≤6.9 m/sec for the period of August to October and ≤5.0 m/sec in November).

Table 4. Turbine rotations per minute (rpm) during bat detection events (number per rpm category) and proportion (percent).

Rpm	Number of events	Proportion
0	313	81.5%
>0–0.5	39	10.2%
>0.5–1.0	2	0.5%
>1.0–5.0	1	0.3%
>5.0–10.0	10	2.6%
>10.0–16.3 (max.)	19	4.9%

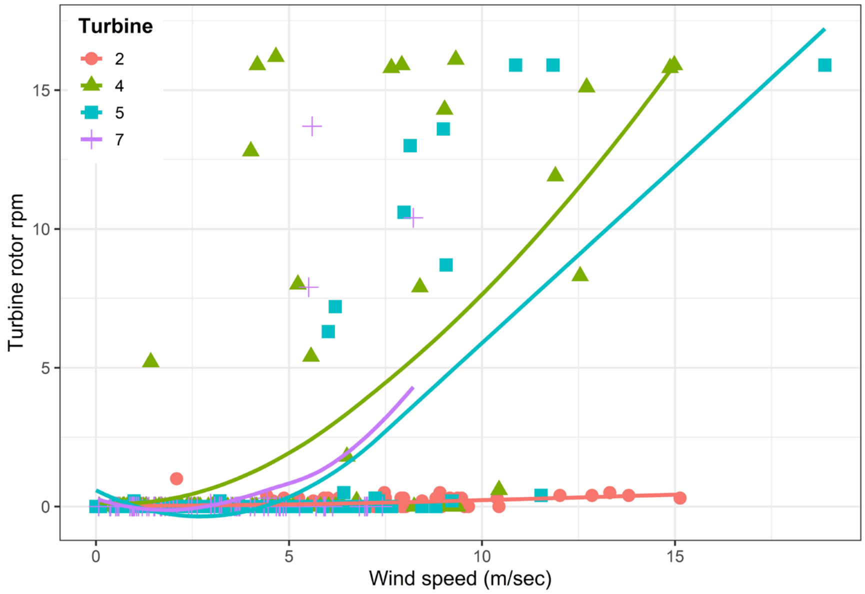

Figure 14. Turbine rotor rotations per minute (rpm) relative to wind speed (m/sec) during bat detection events over the four-month monitoring period. Locally estimated scatterplot smoothing (loess) curves are fit separately for turbines. Wind speed values are specific to the nearest 10-minute interval record. Turbine 2 was not operational, and rpm remained at or near zero until November 20 (10 nights before the end of monitoring).

Nightly bat detection rates for the four-month period of monitoring were negatively correlated with total daily precipitation (Kendall's rank correlation tau = -0.24, $P = 0.0009$). In addition, there were six periods lasting one or more nights with relatively high total daily precipitation (>1 cm) that corresponded with no bat detections or low detection rates (less than the nightly mean of 0.08 events per hour; Appendix I). These periods were associated with the passage of Hurricane Hector (August 9), Hurricane Lane (August 23–26), Tropical Storm Olivia (September 12–13), and strong low pressure systems (September 24–27, October 6–7, October 12) (National Weather Service Monthly Precipitation Summary, www.weather.gov/hfo/hydro_summary, accessed June 6, 2019).

Visual (Thermal Video) Bat Detections—Generalized Linear Mixed Model Analysis

The top-ranked GLMMs consistently included distribution types GP and CMP, indicating that underdispersion was effectively addressed in the final model selection. The weights of the top four models summed to 0.91, with only an additional weight of 0.06 gained from the fifth- and sixth-ranked models combined (Table 5). These models largely demonstrated similar combinations of variables (Table 6; summarized in Appendix II). All top models included either "wind-mean" or "rpm", and each of the models also included either "rpm-starts" or "wind-sd" (neither pairs were included jointly because of their high correlation). Diagnostics demonstrated that the final regression models met assumptions of uniformity and did not exhibit zero inflation (Appendix III), with underdispersion addressed in GP and CMP models. Data used in models are available at https://doi.org/10.5066/P937H9LQ (Gorresen 2020).

Table 5. Generalized linear mixed models ranked by model fit. "Type" refers to model distribution type: generalized Poisson (GP) or Conway-Maxwell-Poisson (CMP). "log *L*" refers to the estimate of the log-likelihood and "DF" refers to model degrees of freedom.

Model	Type	Predictor variables			log *L*	AICc	Δlog *L*	ΔAICc	DF	Weight
1	CMP	rpm	wind-sd	precip	-470.5	955.4	38.8	0.0	7	0.43
2	CMP	rpm	wind-sd		-472.2	956.6	37.2	1.2	6	0.23
3	GP	wind-mean	rpm-starts		-472.7	957.7	36.6	2.3	6	0.14
4	GP	wind-mean	rpm-starts	precip	-471.9	958.1	37.5	2.7	7	0.11
5	GP	wind-mean	wind-sd		-473.8	959.9	35.5	4.5	6	0.04
6	GP	wind-mean	wind-sd	precip	-473.5	961.3	35.8	6.0	7	0.02
7	GP	rpm	precip		-475.2	962.6	34.2	7.2	6	0.01
8	GP	rpm	rpm-starts	precip	-475.2	964.6	34.2	9.2	7	<0.01
9	GP	rpm			-477.9	965.9	31.5	10.6	5	<0.01
10	GP	rpm	rpm-starts		-477.8	967.7	31.6	12.3	6	<0.01
11	GP	wind-mean	precip		-480.0	972.2	29.4	16.8	6	<0.01
12	GP	wind-mean			-481.3	972.7	28.1	17.4	5	<0.01
13	GP	precip			-502.8	1015.7	6.6	60.4	5	<0.01
14	GP	rpm-starts	precip		-502.0	1016.3	7.3	60.9	6	<0.01
15	GP	wind-sd	precip		-502.7	1017.6	6.7	62.2	6	<0.01
16	GP	null			-509.4	1026.8	0.0	71.5	4	<0.01
17	GP	rpm-starts			-508.6	1027.4	0.8	72.0	5	<0.01
18	GP	wind-sd			-509.4	1028.9	0.0	73.5	5	<0.01

Table 6. Standardized model estimates and associated measures from the six top-ranked GLMMs (combined weight = 0.97) predicting the effect of weather and turbine operation variables on the number of nightly bat detections events. Number of observations for all models = 412.

Model	Parameter	Estimate		SE	z value	p-value	Variance
1	Random effect						
	night (Intercept)						0.38
	turbine						0.21
	Conditional model						
	(Intercept)	-3.22	±	0.26	-12.47	<0.0001	
	rpm	-1.13	±	0.14	-8.26	<0.0001	
	wind-sd	0.31	±	0.09	3.29	0.0010	
	precip	-0.27	±	0.17	-1.62	0.1055	
2	Random effect						
	night (Intercept)						0.38
	turbine						0.23
	Conditional model						
	(Intercept)	-3.19	±	0.27	-11.91	<0.0001	
	rpm	-1.18	±	0.13	-8.80	<0.0001	
	wind-sd	0.33	±	0.09	3.60	0.0003	
3	Random effect						
	night (Intercept)						0.42
	turbine						0.02
	Conditional model						
	(Intercept)	-3.17	±	0.14	-22.15	<0.0001	
	wind-mean	-1.08	±	0.13	-8.05	<0.0001	
	rpm-starts	0.40	±	0.09	4.23	<0.0001	
4	Random effect						
	night (Intercept)						0.41
	turbine						0.02
	Conditional model						
	(Intercept)	-3.19	±	0.14	-22.04	<0.0001	
	wind-mean	-1.04	±	0.14	-7.49	<0.0001	
	rpm-starts	0.39	±	0.09	4.12	<0.0001	
	precip	-0.21	±	0.18	-1.16	0.2450	
5	Random effect						
	night (Intercept)						0.42
	turbine						0.00
	Conditional model						
	(Intercept)	-3.15	±	0.13	-24.20	<0.0001	
	wind-mean	-1.09	±	0.14	-7.94	<0.0001	
	wind-sd	0.39	±	0.10	3.95	<0.0001	
6	Random effect						
	night (Intercept)						0.42
	turbine						0.00
	Conditional model						
	(Intercept)	-3.16	±	0.13	-23.97	<0.0001	
	wind-mean	-1.06	±	0.14	-7.335	<0.0001	
	wind-sd	0.37	±	0.10	3.675	0.0002	
	precip	-0.14	±	0.18	-0.743	0.4575	

Acoustic Bat Detections—Descriptive Analyses
Acoustic monitoring at the four turbines yielded 247 turbine-nights of viable recording, comprising 3,036 hours of sampling (including a 15-minute period before sunset and after sunrise; turbine 2 [767.0 hrs], turbine 4 [212.2 hrs], turbine 5 [1,446.7 hrs], turbine 7 [610 hrs]). During this period a total of 1,873 wav sound files with confirmed bat detections were acquired from the rear-facing (leeward) microphone. Detections pooled into groups that occurred within 1 minute of each other totaled to 244 discrete events. Bats were detected acoustically in 31% (n = 75) of the turbine-nights sampled. Acoustic bat detection data are available at https://doi.org/10.5066/P937H9LQ (Gorresen 2020) and are summarized in Appendix I and II.

Acoustic detections of bats at turbines occurred throughout the night, with the earliest detection occurring 25 minutes after sunset and the latest 18 minutes before sunrise. Detections exhibited a unimodal distribution and a median fraction of night time of detection equal to 0.28, corresponding to a peak about 3.3 hours after sunset (Q1 = 0.19, Q3 = 0.40, mean = 0.32 ± 0.18 SD; standardized as a fraction of night and scaled from 0 at sunset to 1 at sunrise; Figure 15). A Welch two-sample t-test (Delacre *et al.* 2017) of the bat observations produced by video and acoustic monitoring found no significant difference in the mean time of detection events between the two sampling methods (t = 1.0592, df = 558.37, *P* = 0.290).

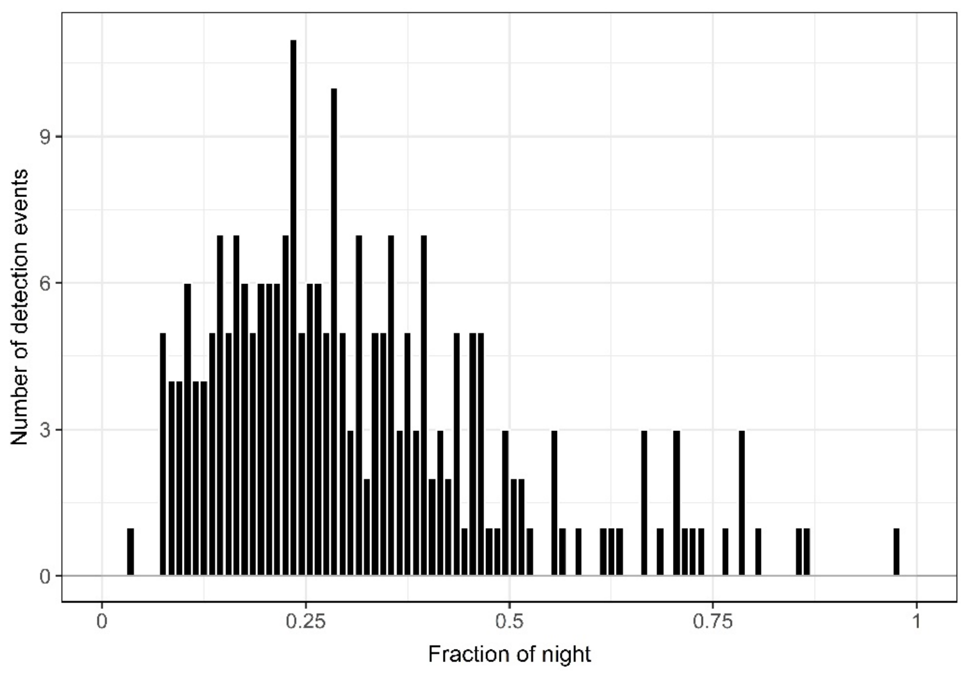

Figure 15. Distribution of acoustic detections of bats by time of night over the four-month monitoring period. To account for seasonal changes in night duration, the time of detection was standardized as a fraction of night and scaled from 0 (sunset) to 1 (sunrise).

The overall mean acoustic detection rate for which data were available was 0.08 events/hour (SD = 0.18; Q1 = 0.00, median = 0.00, Q3 = 0.08). Because the acoustic samples were largely concentrated on the earlier part of the four-month monitoring period (Figure 16), a direct comparison for all turbines combined with the rate obtained from videographic sampling was not possible. However, acoustic samples for turbine 5 were comparable in the span of the monitoring period that matched video samples, and a Welch two-sample t-test found no significant difference in the mean detection rate between the two sampling methods (t = 1.7011, df = 167.11, $P = 0.0978$). Extensive periods with missing acoustic data and uncertainty in the decay rate of microphone sensitivity did not permit a quantitative comparison of detection rates among turbines relative to time of year.

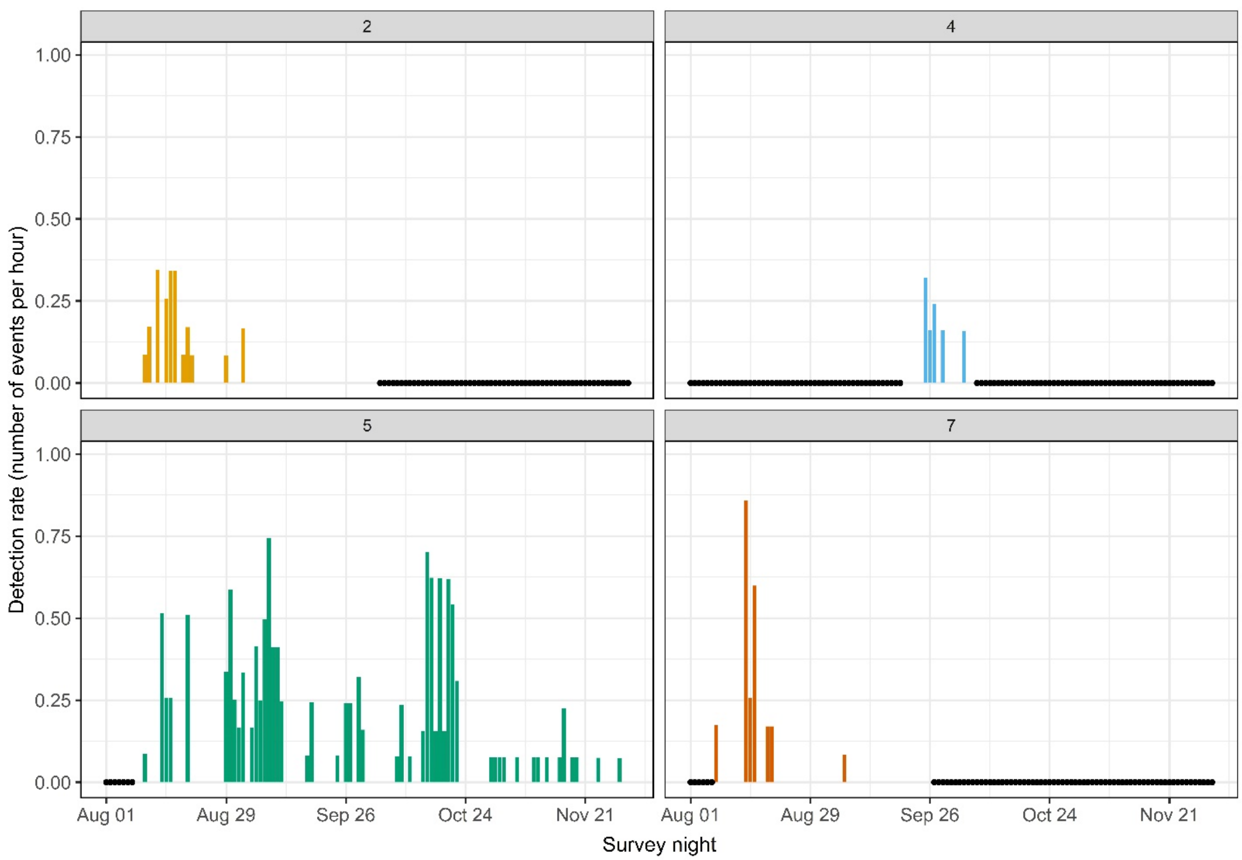

Figure 16. Detection rate of bats (number of events per hour per night) for each of four turbines (2, 4, 5, and 7) over the four-month acoustic monitoring period. Detection rates are adjusted by survey effort (i.e., sample duration within night interval). Nights with no samples are indicated with a black point.

The duration of individual acoustic bat detection events (in part determined by the range acoustic detectors are capable of sampling) averaged 23.2 sec per event. However, 7% (n = 17) of the events lasted 60 sec or more, of which 2% (n = 5) of events lasted ≥120 sec, and one event was sustained for 13.4 minutes (min = 3.0, Q1 = 3.0, median = 6.0, Q3 = 21.0, max

= 803.0 sec). On a per-turbine basis, the nightly cumulative duration of events averaged 76.0 sec (min = 3.0, Q1 = 6.0, median = 36.0, Q3 = 71.0, max = 1,232.0; Figure 17), with the maximum duration (totaling to 20.5 minutes) comprised of 14 individual events (occurring on September 25 at turbine 5). Although the cumulative duration of events appears to more than halve during the four-month period of monitoring, high variance precluded the detection by linear regression of a seasonal change in the duration of bat activity (slope = -0.0446, SE = 0.0329, P = 0.1805; Figure 18). As with the results inferred from visual (thermal video) monitoring, acoustic sampling indicated that bats generally do not appear to be spending much time in the rotor-swept zone. The duration of all detection events totaled to 94 minutes (5,650 sec) over the survey and made up only 0.05% of the total period of acoustic monitoring (1.6 hours of 3,036 total hours). Acoustic detections were infrequent and the time difference between consecutive events within a night averaged 65.4 minutes (min = 1.4, Q1 = 14.4, median = 38.8, Q3 = 74.7, max = 530.6; Figure 19). Most nightly detection events (57%; n = 44) at a turbine were comprised of 10 or fewer "bat passes" (i.e., distinct wav files). More numerous passes were recorded less frequently: >10 to 100 passes (40%; n = 31); >100 passes (3%; n = 2; Figure 20). Terminal-phase (feeding buzz) type calls were only noted in 3% (n = 7) of all events.

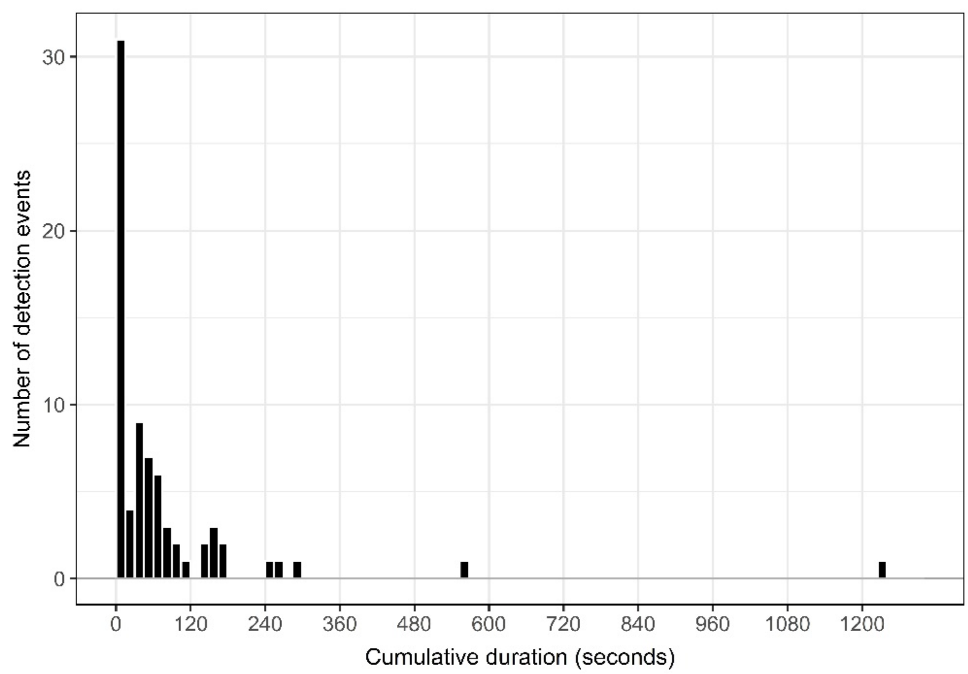

Figure 17. Distribution of the cumulative duration (seconds) of acoustic detection events on a nightly and per-turbine basis over the four-month monitoring period.

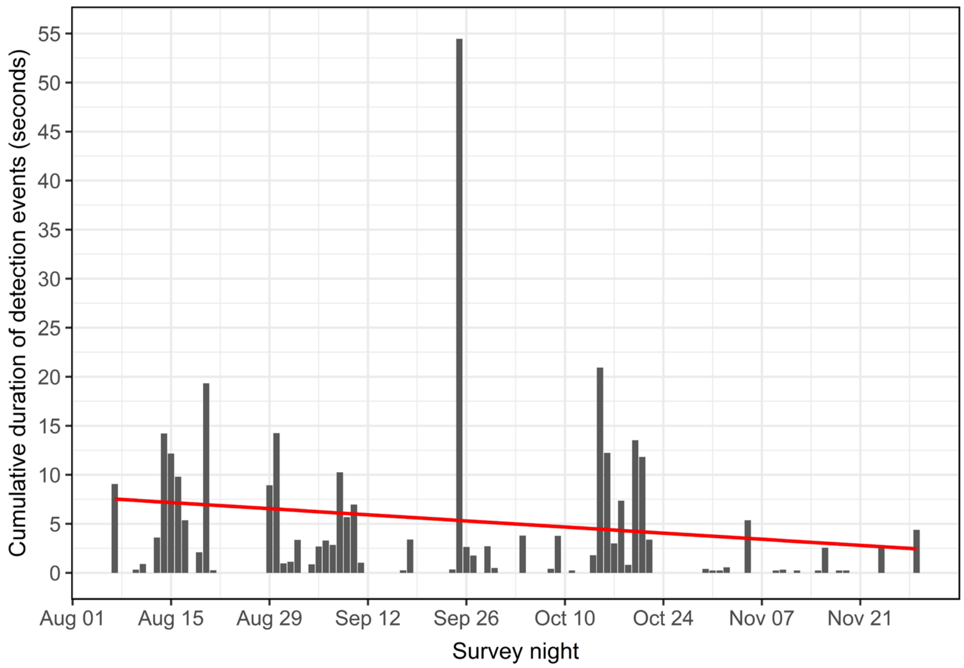

Figure 18. Cumulative duration (seconds) of acoustic detection events (adjusted for total nightly sampling duration for all turbines) over the four-month monitoring period. The red line is a linear model of trend in event duration.

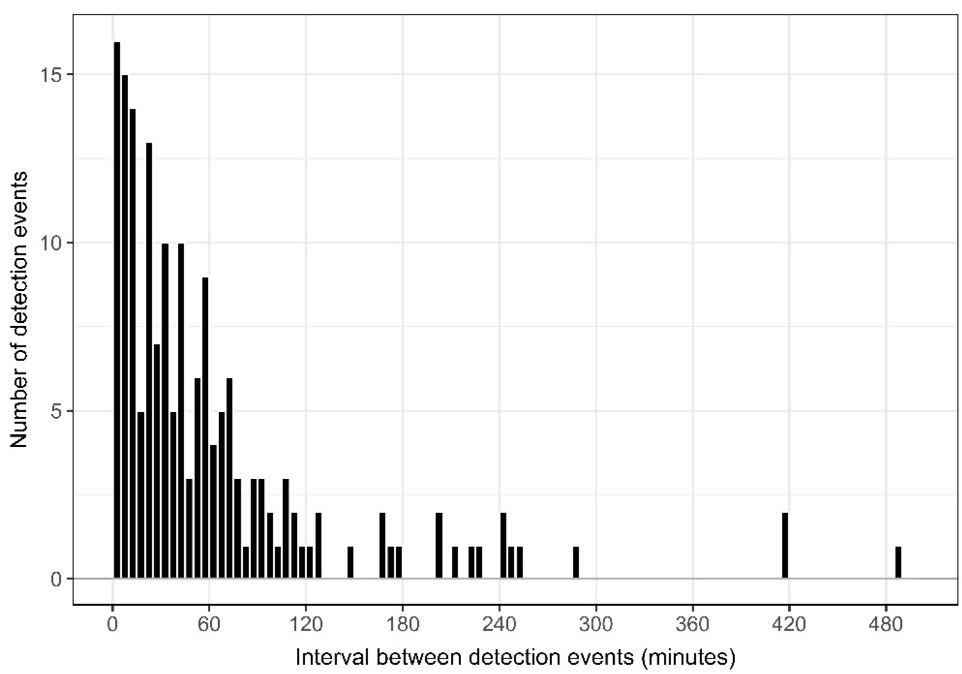

Figure 19. Distribution of the time interval (minutes) between consecutive acoustic detections of bats within a night over the four-month monitoring period.

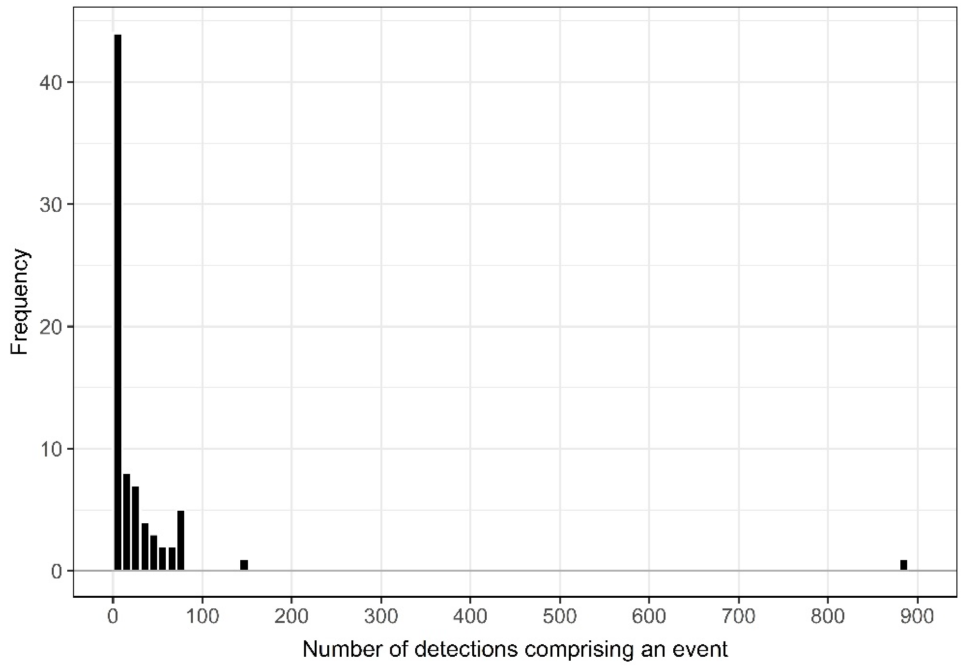

Figure 20. Distribution of the number of discrete detections (wav sound files measuring "bat passes") that comprised events over the four-month monitoring period.

The correspondence between acoustic and visual detection events at a turbine were examined at three scales: the entire night (averaging approximately 12 hours); a 2-hour period (i.e., an acoustic detection 1 hour before or after a visual detection); and a 10-minute period (i.e., an acoustic detection 5 minutes before or after a visual detection). A total of 187 turbine-nights was concurrently sampled both acoustically and visually. Of this subset, acoustic detections (regardless of whether it was also detected visually) composed 33% (n = 62) of the concurrently sampled turbine-nights (Table 7). Acoustic samples confirmed bat presence on 56% (= 45/81) of the turbine-nights for which bats were also detected visually with thermal cameras at some point during the night. Bats were not detected by either method during 48% (n = 89) of the concurrent sample.

Table 7. Proportion of concurrently sampled turbine-nights (n = 187) with bat detections.

Sample method	Nights bats detected
Both visual & acoustic	45 (24%)
Visual only	36 (19%)
Acoustic only	17 (9%)
Neither method	89 (48%)
Visual only plus both visual & acoustic	81 (43%)
Acoustic only plus both visual & acoustic	62 (33%)

At a finer temporal scale, there were a total of 294 visual detection events during the concurrently sampled period, of which 22% (n = 65) of acoustic detections occurred within a 2-hour window of a visual detection, and of these, a subset of 12% (n = 36) occurred within a 10-minute window. Conversely, a total of 229 visual detection events did not have an acoustic match within a 2-hour window, even though 65% (n = 149) of these involved a bat making a close approach to the nacelle (i.e., within approximately 15 m).

Discussion

Our findings reveal new information about the potential effects of wind speed and turbine operation on the presence and behavior of Hawaiian hoary bats occurring on the coast of southwest Maui. We used complementary observation technologies (sound recordings and video imaging) over four months to document distinct seasonal and nightly patterns in the occurrence and activity rates of hoary bats at the Auwahi Wind Energy facility. Overall, the picture emerging from these results is that individual hoary bats from other parts of the island sporadically visit the wind facility, usually before midnight, dwell in the airspace near each turbine for a few seconds (probably searching for insect prey), and then move out of the area without returning for several nights. Bat activity patterns across the local landscape were likely affected by the presence of wind turbines, weather conditions, and possibly operational changes implemented as mitigation efforts. These findings offer unique perspective toward broadening our understanding of the behavioral reasons why bats might regularly approach wind turbines, gauging the efficacy of different monitoring and research technologies, and point to new possibilities for fatality reduction.

We observed bat activity at the Auwahi wind turbines from early August through late November of 2019. Although this timespan represents an intensive field and analysis effort, it only covered one-third of an annual cycle during a single year, so our conclusions are based on conditions that happened to occur at the study site during this period. Lacking additional longer-term, site-specific information, the following discussion assumes that the patterns we report are representative of typical bat visitation, weather conditions, and turbine operation at the site.

Although we detected a slight downward trend in bat visitation to the wind turbines from August through November of 2019, bat activity was consistently low and sporadic. This downward seasonal trend differs from more distinct patterns of hoary bat activity observed at wind facilities studied using comparable methods on nearby islands (Gorresen *et al.* 2015b) and on the U.S. mainland (Cryan *et al.* 2014). At a wind facility on the island of O'ahu, bat visitation to turbines increased during a six-month study period spanning from mid-May through mid-November of 2013, peaking in November (Gorresen *et al.* 2015b). We are not aware of other comparable data sets relevant to Hawaiian hoary bats. On the U.S. mainland and Canada, hoary bat fatality and video activity at wind turbines generally begins increasing in mid-June, tends to peak in September, then decreases by October and November (Arnett and Baerwald 2013, Cryan *et al.* 2014).

The question of whether bat activity and presumably collision risk in Hawai'i is seasonally consistent or peaks during certain times of year remains unanswered. The hypothesis that seasonal peaks in hoary bat fatalities at turbines on the mainland have more to do with migration than other factors (Cryan and Barclay 2009), and thus the non-migratory Hawaiian hoary bat would be less susceptible, is yet untested. The possibility remains that factors other than migration, such as feeding or mating strategies that trigger bat investigation of tall landscape structures, primarily drive the seasonal peaks of bat fatalities observed elsewhere (Cryan and Barclay 2009, Cryan *et al.* 2014). Considering our results and available information, seasonal peaks in bat activity and fatality rates at wind turbines may occur in Hawai'i too, yet to our knowledge relevant year-long observations of occurrence combined with fatality monitoring have not been made at a sufficient number of wind energy facilities within the range of the Hawaiian hoary bat to discern whether or not a distinct and consistent seasonal peak occurs. Clearly establishing the existence and temporal consistency of seasonal peaks in bat activity at wind turbines has clear implications toward design and implementation of operational fatality reduction strategies.

We observed both similarities and differences in the nightly activity patterns of bats at the Auwahi Wind Energy facility compared to those uncovered using similar methods at turbines on O'ahu and the U.S. mainland. The bat detection rate at the Auwahi Wind Energy facility, measuring in the hundredths of bat detections per hour over the approximately 5,000 hours of video observation, was much lower than that observed during a comparable video-based study on O'ahu. The detection rate at the Auwahi Wind Energy facility was about an order of magnitude lower than was observed at turbines in an upland forest site on O'ahu, where bat detections numbered in the tenths (0.88) per hour over almost 4,000 hours of video, and which also included additional months with low bat activity (mid-May through July; Gorresen *et al.* 2015b). Similar to patterns observed on the U.S. mainland, hoary bat activity around the turbines at the Auwahi Wind Energy facility mostly occurred during the first half of the night, although bats were sometimes active in the hours before dawn (Cryan *et al.* 2014). This nightly activity pattern of a single activity peak more than an hour after sunset yet before midnight differs from that documented over six months at the upland forest turbines on O'ahu in 2013, where detections showed not only an earlier primary peak immediately after sunset, but also a smaller secondary peak in the hours just before dawn (Gorresen *et al.* 2015b).

Possible explanations for the single, lower, and slightly later nightly activity peak of Hawaiian hoary bats at the Auwahi Wind Energy facility include individuals having to commute to the site after emerging from roosts at sunset in nearby habitats (likely forests), and environmental conditions that potentially draw bats to turbines from the broader landscape being more likely to occur at that time. On O'ahu, the peaks of highest bat detections coincided with sunset and sunrise, indicating that bats were likely to visit turbines immediately after emerging from or returning to roosts in the surrounding forest. The lack of such crepuscular activity peaks at the Auwahi Wind Energy facility lead us to believe that bats visiting the turbines there do not roost during the daytime at or near the site, but instead reach the turbines by flying from more distant locations—probably tree roosts in denser forest stands, the closest of which are about 7 km away. The pattern also indicates bats do not regularly visit the Auwahi Wind Energy facility turbines in the hours before sunrise. The possibility of early nighttime environmental conditions that might draw bats to turbines are discussed below.

In addition to generally observing fewer visits by bats, a delayed post-sunset activity peak, and the lack of a pre-dawn activity peak, another notable pattern in the nightly activity of bats at the Auwahi Wind Energy facility was their sporadic occurrence at the wind facility from night to night. Our results indicate that when bats visit the wind facility, they tend to dwell around the turbines for slightly longer on a per-visit basis than was observed in upland forest at the wind facility on O'ahu. The duration of individual bat detection events at the Auwahi Wind Energy facility averaged 23.5 sec and were about six times longer than the duration of detections recorded at the O'ahu forest site, which averaged 4.0 sec per event (Gorresen *et al.* 2015b). However, the cumulative amount of time bats spent around a turbine on a nightly basis was remarkably similar between the two studies, with cumulative times totaling about 40 and 50 sec per turbine per night at the site on O'ahu and at the Auwahi Wind Energy facility, respectively (Gorresen *et al.* 2015b). These findings show that although Hawaiian hoary bats visit the Auwahi Wind Energy facility less frequently, their longer nightly visits could result in individuals spending an equivalent amount of time per night around turbines as at the forested site on O'ahu. However, patterns in the spacing of bat detections at the Auwahi Wind Energy facility within and among nights indicates potential differences in the way bats perceive and interact with wind turbines there compared to other sites.

Two notable patterns we observed at the Auwahi Wind Energy facility were the correlation of bat detections among turbines and the relatively long and unpredictable time periods between consecutive detection events, both within and among nights. Within a given night, visiting bats tended to dwell at the site and were likely to visit many of the turbines before leaving. When they did leave the site, an average of 1 hour 20 minutes elapsed before another bat was detected. On a night-to-night basis, bat occurrence was sporadic and unpredictable. That is, a Hawaiian hoary bat using the wind facility on a given night may not be strongly predictive of a bat occurring there again on subsequent nights or be strongly influenced by cyclic or other night-to-night patterns caused by short-term factors or predictable environmental conditions (at least within the 12-night analysis window we examined). The relatively infrequent, unpredictable, and lingering observations of Hawaiian hoary bats detected at the Auwahi Wind Energy facility could be attributable to certain wide-ranging individuals sporadically but repeatedly commuting to the site from distant roosting areas, multiple wide-ranging individuals haphazardly encountering the turbines during more randomly directed landscape movements, or some combination of these scenarios. Activity patterns of Hawaiian hoary bats observed in forested habitats on O'ahu led to speculation that those individual bats were familiar with turbines interspersed among their roosting and foraging grounds, and the resources (e.g., prey, mates, etc.) available at those structures (Gorresen *et al.* 2015b). It remains to be determined whether bats visiting turbines at the Auwahi Wind Energy facility are naïve to the resources sought at the turbines or if they become familiar and less risk-prone as experienced individuals.

The relatively longer periods of observation per bat visit at the Auwahi Wind Energy facility gave us better opportunities than in previous studies to determine why those hoary bats might have been flying in the airspace near the turbines. The duration of all detection events in this study totaled only 2.5 hours and made up only 0.05% of the entire period of video monitoring. This cumulative total was less than in the study at turbines in upland forest on O'ahu, where bat video observations totaled about 3.8 hours and represented 0.1% of video analyzed (Gorresen *et al.* 2015b). As discussed above, despite less frequent detections at the Auwahi Wind Energy facility, the longer duration of events there resulted in the cumulative period of bat detections per turbine per night being similar between the two studies. However, bats at the Auwahi Wind Energy facility were observed for proportionally longer periods per detection event, giving us more opportunities to accurately discern behaviors during these typically brief encounters.

Eight out of ten of the observations of Hawaiian hoary bats around wind turbines at the Auwahi Wind Energy facility involved erratic flight indicative of bats engaged in foraging behavior. Only a small proportion of events involved straight, directed flight past the turbines, suggestive of bats quickly transiting the rotor-swept airspace. The proportion of events involving foraging-like flight at the Auwahi Wind Energy facility was approximately double that documented during the study on O‘ahu, where turbines were situated in upland forest, and bat activity correlated to insect activity (Gorresen *et al.* 2015b). A 2017 videographic survey of upland habitats on O‘ahu (including the wind facility mentioned previously) also showed that most bat detection events involved single passes involving straight and directed flight, suggestive of samples obtained from bats moving within frequently traversed home ranges (Gorresen *et al.* 2018). The bats at the Auwahi Wind Energy facility may have been concentrating their flight and associated search for food disproportionately more on the wind turbines than on surrounding habitats, whereas those observed on O‘ahu may have been primarily moving through the habitats with ample feeding opportunities surrounding the turbines and thus spending proportionally less time focusing on the turbines. Overall, our observations indicate bats travel from distant roost sites to the remote but potentially focal foraging area around the Auwahi Wind Energy facility turbines, search promising habitat features (including the turbines themselves) for insect prey, then leave and only infrequently return during the same or subsequent nights. In contrast, the proportionally lower incidence of foraging-like behavior observed around turbines in forested uplands of O‘ahu might have been attributable to those turbines being situated amidst more favorable alternative foraging prospects.

Regardless of why bats entered the airspace around wind turbines at the Auwahi Wind Energy facility, more than half of the detection events involved individuals flying within an estimated 15 m of the turbine nacelle. This regular and consistently observed close-approach behavior, combined with relatively few observations of bats being displaced by moving blades and no observation of strikes, indicates that the presence of Hawaiian hoary bats in the rotor-swept zone of a turbine may not be directly proportional to their risk of being injured, particularly when presence is considered independent of wind speed. Systematic ground-based carcass searches resulted in no documented bat fatalities at the four turbines during the four-month monitoring period (Tetra Tech 2019).

The activity of bats is generally believed to decrease with increasing wind speed (Weller and Baldwin 2012, Korner-Nievergelt *et al.* 2013), as strong winds can influence the abundance and activity of insects (Erkert 1982). The results from the Auwahi Wind Energy facility are mostly consistent with these trends, although nearly one-fifth of our bat observations were made when wind speeds were greater than the mitigation cut-in speed of 6.9 m/sec. When we modeled the influence of environmental conditions on the probability of hoary bats occurring at the Auwahi Wind Energy facility, results revealed that bat occurrence was negatively related to wind speed, averaged over 10-minute intervals, and possibly declined after or during rain events (although available precipitation data made it difficult to clearly test for the influence of rain at the nightly temporal scale we used for the analysis). Despite the apparent relation of bat detection rates with wind speed and precipitation (both negative), the relation was not predictable—considerable variation was present in the modeled response of bats to weather. We found that low detection rates could occur when conditions appeared favorable, such as when there was no wind and wind speeds were low. Conversely, high detection rates may occur during relatively unfavorable conditions. For example, the largest observed detection rate we documented (nearly a bat per hour) occurred on the night of 15 November when turbine blade rotation averaged 7.1 rpm, wind speed averaged 5.7 m/sec, and wind speed variability, blade rotation intermittency, and light precipitation were also similar to the average conditions observed during the entire four-month study period. Such an event does not seem predictable given available information, but this does not mean that predictable associations among bat occurrence, environmental conditions, and turbine operation do not exist.

Our study objective was to learn more about how bat behaviors at wind turbines relate to wind speed and turbine operation—key elements of effective mitigation strategies for minimizing fatalities of Hawaiian hoary bats. In assessing possible reasons for bat occurrence near the turbines at the Auwahi Wind Energy facility during high wind conditions, we evaluated our data in the context of behaviors we observed on video and the unique turbine operational conditions observable due to the relatively high curtailment cut-in wind speed of 6.9 m/sec. One of the patterns that clearly emerged from the data was that bats were more likely to be detected at turbines when the blades were not moving or were moving slowly, although perhaps not proportional to what would be expected due to wind speed alone in part because of curtailment. However, it is noteworthy that the bat detection rate at the non-operational turbine (WTG2) was similar to the overall mean and not found to be significantly different from the other three operational turbines. This may indicate that fast turbine blade movement is not a causal factor related to the attraction of bats and their presence at turbines. Nevertheless, variability in wind speed and turbine blade rotation intermittency were both positively related to bat detection probability in our analysis. Nearly one-fifth of the observations of bats at the Auwahi Wind Energy facility turbines occurred during conditions when wind speeds exceeded the 6.9 m/sec threshold, indicating that responding to wind-speed alone may not maximize opportunities to produce energy and avoid bat fatalities. When discussing similar results from a video study of bat activity at wind turbines on the U.S. mainland, Cryan *et al.* (2014) speculated "…observations that tree bats show a tendency to closely investigate inert turbines and sometimes linger for minutes to perhaps hours (in the cases of clustered observations) highlight the plausibility of a scenario in which bats are drawn toward turbines in low winds, but sometimes remain long enough to be put at risk when wind picks up and blades reach higher speeds. Therefore, the frequency of intermittent, blade-spinning wind gusts within such low-wind periods might be an important predictor of fatality risk; fatalities may occur more often when turbine blades are transitioning from potentially attractive (stationary or slow) to lethal (fast) speeds."

Such a scenario may be compatible with our observations and analysis from the Auwahi Wind Energy facility. For example, of the proportionally small sample of 34 bat events we observed when turbine blades were moving more than one-half a rotation per minute, eight ensued when wind speeds were below the curtailment threshold. These events may have occurred because of computational lags over the 10-minute period within which the rolling average wind-speed calculated included occasional interludes during which winds dropped below the cut-in threshold but did not yet trigger curtailment. Combining these observations with earlier discussion that bats visiting the Auwahi Wind Energy facility might periodically and intensely search the turbines for feeding opportunities, a plausible hypothesis emerges: Hawaiian hoary bats might occur at the Auwahi Wind Energy facility during variable wind periods because windy periods concentrate insects on the lee of emergent features (e.g., trees), and when winds slacken bats might take the opportunity to focus foraging on the ephemeral concentrations of prey. In other words, relative to calm wind conditions, bats may opportunistically exploit certain landscape features during lulls on otherwise windy nights. A prerequisite for opportunistic use of tall structures such as wind turbines is that they be visually conspicuous and attract bats. This is largely supported by research demonstrating that, relative to surrounding landscapes, the activity of tree bats at tall structures increases as individuals encounter these features during migration in late summer and autumn (Jameson and Willis 2014).

Our study was not able to make optimal use of combined sampling methods because of the poor quality of acoustic data. Fortunately, video cameras functioned more consistently and produced more useful data for drawing inferences about bat presence and behaviors at the turbines than acoustic detectors. Known limitations of the acoustic detection process and potentially cryptic vocalization behavior of hoary bats were concerns going into this study, as well as likely only a modest overlap of the airspace sampled by the two methods (bats could be out of the video field of view, and video can also image farther than an acoustic detector can sample). In general, we confirmed that the range of acoustic detectors was different, less consistent across conditions, and generally lower than thermal surveillance cameras in this study. Although it is clear that Hawaiian hoary bats are acoustically active when present at Auwahi Wind Energy facility, it also appears that the species exhibits, to some extent, the cryptic vocalization noted in other settings (Gorresen *et al.* 2017, Corcoran and Weller 2018). Although both video and acoustic sampling had similar detection rates for the entire four-month monitoring period (albeit not directly comparable because acoustic sampling was weighted towards the earlier months during which nightly bat detections were more prevalent), there was a clear mismatch in the incidence and proportion of samples with bat detections. For the subset of concurrently sampled turbine-nights, acoustic detectors confirmed bat presence in about three-quarters of the turbine-nights for which bats were also detected by thermal cameras. Acoustic bat detectability further declined at finer-resolution time periods of sampling, such as hourly and 10-minute intervals at which video monitoring determined bat occurrence. The frequent lack of detections within a reasonable window for informing acoustically triggered turbine curtailment may have implications for the effectiveness of this method in reducing fatalities, at least in the setting examined in this study. The nature and variability of vocalization by bats at tall structures such as turbines, as well as the operational limits of the detection system, warrants further investigation using both acoustic and videographic methods.

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APPENDIX I

Table 1. Total nightly bat visual (video) and acoustic detection events and respective detection rates (combined and adjusted for sampling effort for all four turbines). Additional supporting information (including detection events by turbine) are available as a U.S. Geological Survey data release at https://doi.org/10.5066/P937H9LQ. Total daily precipitation (cm) obtained from weather station USGS 203721156151601 (Kepuni Gulch Rain Gage, Maui, Hawaii, located 7.3 km ENE from Auwahi Wind Energy, LLC, at 226 m above local mean sea level) is available at: https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=203721156151601; also available at https://doi.org/10.5066/F7P55KJN.

Date	Total visual detection events	Visual detection rate	Total acoustic detection events	Acoustic detection rate	Daily precipitation (cm)
8/1/2018	1	0.029	0	0.000	0.00
8/2/2018	13	0.378	0	0.000	0.00
8/3/2018	5	0.146	0	0.000	0.00
8/4/2018	2	0.058	0	0.000	0.00
8/5/2018	1	0.029	0	0.000	0.00
8/6/2018	10	0.224	0	0.000	0.00
8/7/2018	8	0.173	2	0.087	0.00
8/8/2018	1	0.029	0	0.000	0.00
8/9/2018	0	0.000	0	0.000	1.73
8/10/2018	2	0.111	2	0.058	0.00
8/11/2018	0	0.000	2	0.058	0.46
8/12/2018	0	0.000	0	0.000	0.00
8/13/2018	3	0.129	4	0.115	0.00
8/14/2018	15	0.644	16	0.458	0.00
8/15/2018	2	0.086	9	0.257	0.00
8/16/2018	11	0.290	14	0.400	0.00
8/17/2018	6	0.172	4	0.114	0.20
8/18/2018	0	0.000	0	0.000	0.00
8/19/2018	5	0.128	3	0.085	0.00
8/20/2018	10	0.283	10	0.284	0.00
8/21/2018	0	0.000	1	0.028	0.00
8/22/2018	0	0.000	0	0.000	0.81
8/23/2018	1	0.021	0	0.000	1.30

Date	Total visual detection events	Visual detection rate	Total acoustic detection events	Acoustic detection rate	Daily precipitation (cm)
8/24/2018	0	0.000	0	0.000	4.17
8/25/2018	0	0.000	0	0.000	2.29
8/26/2018	0	0.000	0	0.000	2.21
8/27/2018	0	0.000	0	0.000	0.13
8/28/2018	0	0.000	0	0.000	0.03
8/29/2018	4	0.112	5	0.140	0.00
8/30/2018	1	0.028	7	0.196	0.00
8/31/2018	3	0.085	3	0.084	0.00
9/1/2018	1	0.028	2	0.056	0.00
9/2/2018	5	0.208	6	0.167	0.00
9/3/2018	2	0.083	0	0.000	0.00
9/4/2018	5	0.208	2	0.055	0.00
9/5/2018	3	0.124	5	0.138	0.00
9/6/2018	1	0.031	4	0.111	0.00
9/7/2018	4	0.084	6	0.166	0.00
9/8/2018	4	0.110	9	0.248	0.00
9/9/2018	8	0.165	5	0.138	0.00
9/10/2018	8	0.165	5	0.137	0.00
9/11/2018	2	0.041	3	0.082	0.00
9/12/2018	0	0.000	0	0.000	4.47
9/13/2018	0	0.000	0	0.000	0.79
9/14/2018	1	0.028	0	0.000	0.00
9/15/2018	0	0.000	0	0.000	0.00
9/16/2018	4	0.109	0	0.000	0.00
9/17/2018	1	0.027	1	0.027	0.00
9/18/2018	5	0.135	3	0.081	0.00
9/19/2018	0	0.000	0	0.000	0.00
9/20/2018	0	0.000	0	0.000	0.00
9/21/2018	0	0.000	0	0.000	0.00
9/22/2018	0	0.000	0	0.000	0.00
9/23/2018	0	0.000	0	0.000	0.30
9/24/2018	2	0.054	1	0.020	0.97
9/25/2018	5	0.134	18	0.362	0.05

Date	Total visual detection events	Visual detection rate	Total acoustic detection events	Acoustic detection rate	Daily precipitation (cm)
9/26/2018	2	0.054	5	0.100	0.00
9/27/2018	2	0.080	6	0.160	0.46
9/28/2018	0	0.000	0	0.000	0.03
9/29/2018	6	0.160	6	0.160	0.05
9/30/2018	0	0.000	2	0.053	0.00
10/1/2018	1	0.027	0	0.000	0.00
10/2/2018	2	0.053	0	0.000	0.00
10/3/2018	5	0.132	0	0.000	0.00
10/4/2018	8	0.211	2	0.079	0.00
10/5/2018	1	0.023	0	0.000	0.89
10/6/2018	5	0.099	0	0.000	1.88
10/7/2018	0	0.000	0	0.000	5.79
10/8/2018	2	0.039	1	0.079	0.20
10/9/2018	12	0.236	3	0.236	0.00
10/10/2018	8	0.157	0	0.000	0.00
10/11/2018	1	0.020	1	0.079	0.00
10/12/2018	4	0.157	0	0.000	1.83
10/13/2018	1	0.026	0	0.000	0.08
10/14/2018	14	0.273	2	0.156	0.00
10/15/2018	13	0.253	9	0.703	0.00
10/16/2018	8	0.156	8	0.624	0.00
10/17/2018	6	0.117	2	0.156	0.00
10/18/2018	6	0.161	8	0.622	0.00
10/19/2018	5	0.098	2	0.155	0.00
10/20/2018	3	0.058	8	0.620	0.00
10/21/2018	11	0.213	7	0.542	0.00
10/22/2018	7	0.154	4	0.309	0.00
10/23/2018	0	0.000	0	0.000	0.00
10/24/2018	2	0.038	0	0.000	0.00
10/25/2018	1	0.019	0	0.000	0.00
10/26/2018	2	0.044	0	0.000	0.00
10/27/2018	2	0.038	0	0.000	0.03
10/28/2018	0	0.000	0	0.000	0.00

Date	Total visual detection events	Visual detection rate	Total acoustic detection events	Acoustic detection rate	Daily precipitation (cm)
10/29/2018	0	0.000	0	0.000	0.13
10/30/2018	3	0.076	1	0.076	0.10
10/31/2018	1	0.019	1	0.076	0.03
11/1/2018	4	0.076	1	0.076	0.00
11/2/2018	5	0.096	1	0.076	0.00
11/3/2018	0	0.000	0	0.000	0.20
11/4/2018	1	0.019	0	0.000	0.20
11/5/2018	8	0.152	1	0.076	0.00
11/6/2018	0	0.000	0	0.000	0.00
11/7/2018	0	0.000	0	0.000	0.00
11/8/2018	2	0.038	0	0.000	0.00
11/9/2018	3	0.077	1	0.075	0.00
11/10/2018	4	0.100	1	0.075	0.00
11/11/2018	6	0.113	0	0.000	0.00
11/12/2018	2	0.075	1	0.075	0.00
11/13/2018	1	0.025	0	0.000	0.00
11/14/2018	2	0.067	0	0.000	0.03
11/15/2018	18	0.369	1	0.075	0.23
11/16/2018	6	0.114	3	0.225	0.00
11/17/2018	0	0.000	0	0.000	0.00
11/18/2018	1	0.019	1	0.075	0.00
11/19/2018	6	0.149	1	0.075	0.00
11/20/2018	0	0.000	0	0.000	0.00
11/21/2018	0	0.000	0	0.000	0.00
11/22/2018	0	0.000	0	0.000	0.76
11/23/2018	0	0.000	0	0.000	0.00
11/24/2018	1	0.019	1	0.074	0.00
11/25/2018	4	0.085	0	0.000	0.00
11/26/2018	0	0.000	0	0.000	0.00
11/27/2018	1	0.025	0	0.000	0.00
11/28/2018	0	0.000	0	0.000	0.00
11/29/2018	0	0.000	1	0.074	0.18
11/30/2018	0	0.000	0	0.000	0.00

APPENDIX II

Table 1. Summary of the number of nightly visual (video) and acoustic bat detection events per turbine, detection rate (number of detection events per hour, calculated as the nightly total of events divided by sample duration at a turbine), and the nightly metrics of weather and turbine operation variables, including precipitation ("precip"; total in cm for a 24-hour midnight-to-midnight period centered on the day of the record), mean wind speed ("wind-mean"; calculated as the mean of 10-minute interval recordings), variability in wind speed ("wind-sd"; calculated as the standard deviation of 10-minute interval recordings), turbine blade movement ("rpm"; rotations per minute), and turbine starts ("rpm-starts"; calculated as the total of such events following one or more 10-minute intervals at which the blade was motionless). Values include minimum, 1st quartile, median, mean, 3rd quartile, and maximum. All weather and turbine operation variables used in regression analysis were standardized and centered on the variable mean (i.e., subtracting variable values by its grand mean and dividing by its standard deviation). See methods for description of data sources. Additional supporting information are available as a U.S. Geological Survey data release at https://doi.org/10.5066/P937H9LQ.

Values	Visual detection events	Visual detection rate	Acoustic detection events	Acoustic detection rate	Precip	Wind-mean	Wind-sd	Rpm	Rpm-starts
Min:	0.000	0.000	0.000	0.000	0.000	0.985	0.745	0.000	0.000
1Q:	0.000	0.000	0.000	0.000	0.000	3.865	1.570	0.160	1.000
Median:	0.000	0.000	0.000	0.000	0.000	7.098	2.125	4.293	2.000
Mean:	0.934	0.077	0.988	0.081	0.271	7.336	2.178	6.394	3.879
3Q:	1.000	0.087	1.000	0.077	0.030	10.252	2.676	13.020	5.000
Max:	12.000	0.899	14.000	1.125	5.790	21.021	4.886	16.210	21.000

APPENDIX III

Figures 1–6. Post-model-fitting diagnostics performed with the DHARMa package (Hartig 2017). Diagnostics demonstrated that the six top-ranked regression models (listed in Tables 5 and 6) met assumptions of uniformity (left panels) and did not exhibit zero inflation (right panels).

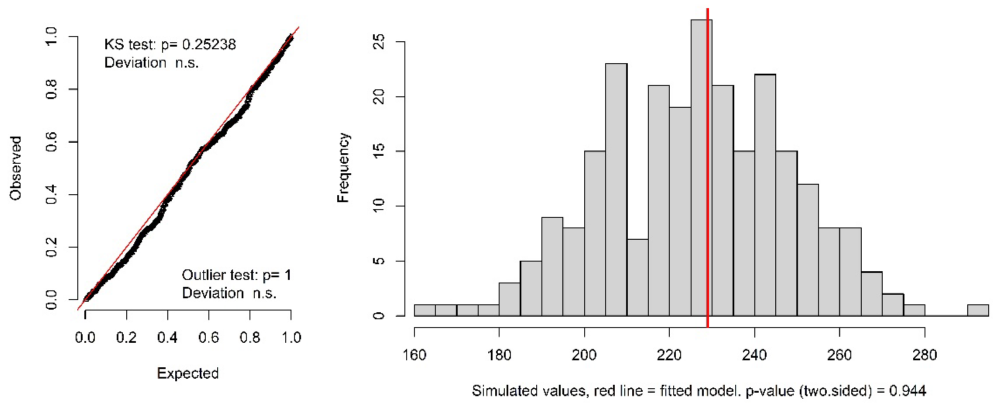

Figure 1. Model 1 of six top-ranked regression models. Left panel shows model met assumptions of uniformity, and right panel displays model did not exhibit zero inflation.

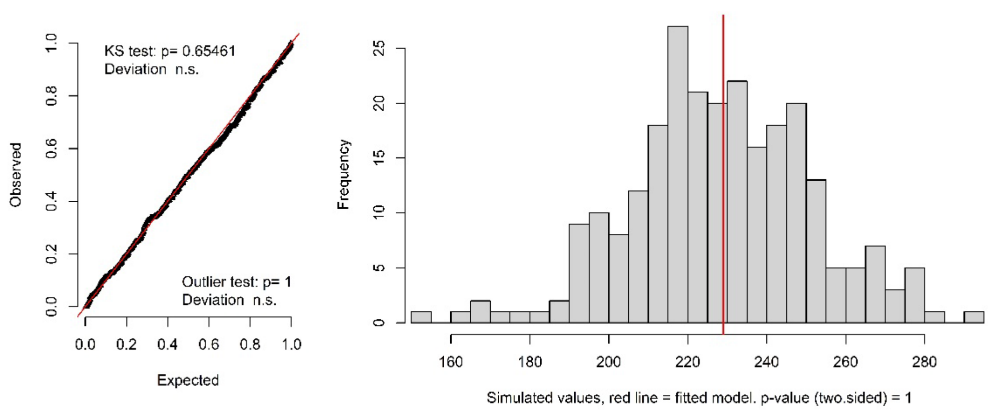

Figure 2. Model 2 of six top-ranked regression models. Left panel shows model met assumptions of uniformity, and right panel displays model did not exhibit zero inflation.

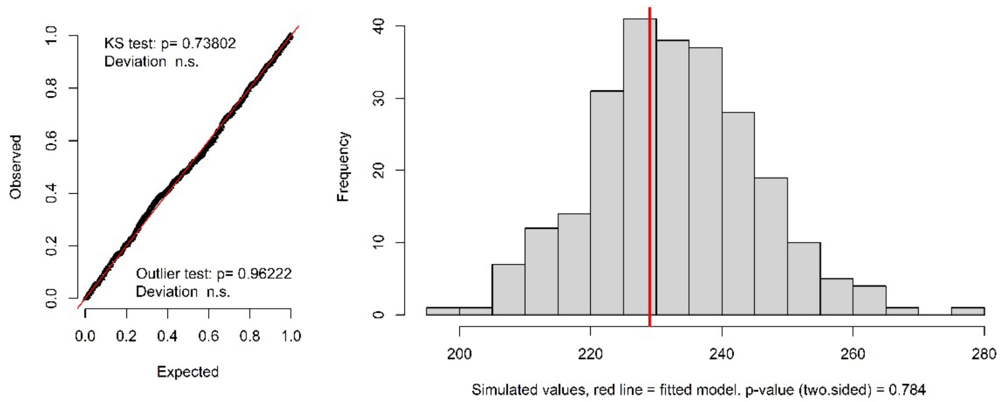

Figure 3. Model 3 of six top-ranked regression models. Left panel shows model met assumptions of uniformity, and right panel displays model did not exhibit zero inflation.

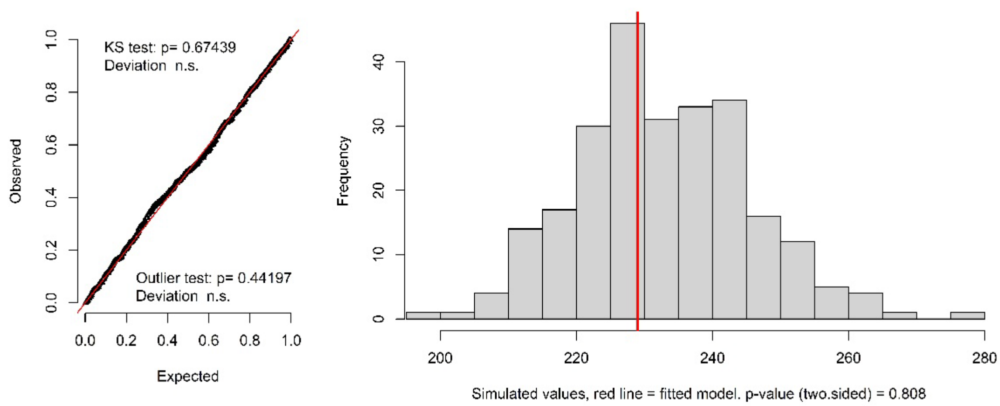

Figure 4. Model 4 of six top-ranked regression models. Left panel shows model met assumptions of uniformity, and right panel displays model did not exhibit zero inflation.

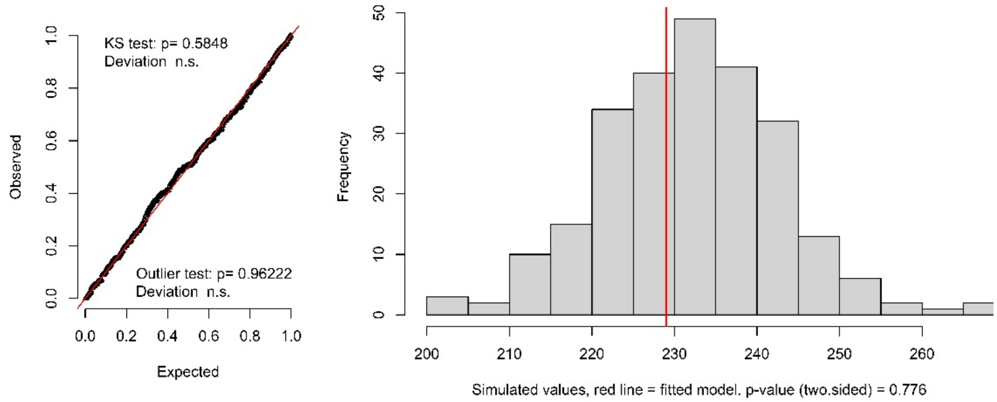

Figure 5. Model 5 of six top-ranked regression models. Left panel shows model met assumptions of uniformity, and right panel displays model did not exhibit zero inflation.

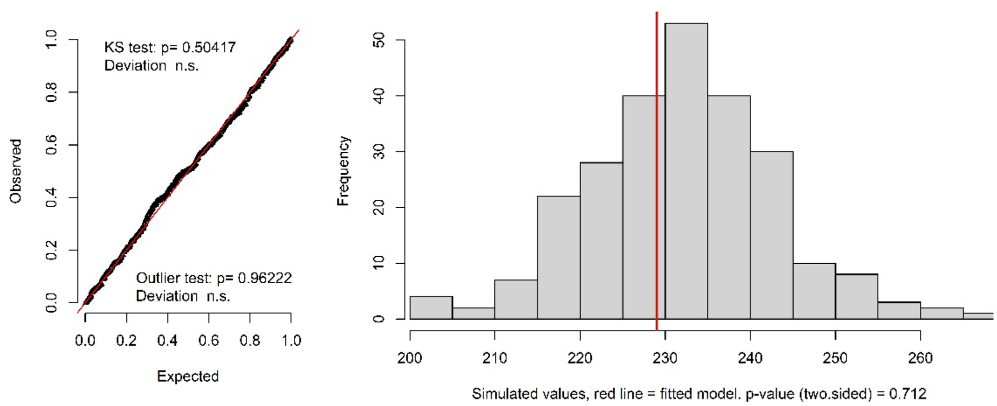

Figure 6. Model 6 of six top-ranked regression models. Left panel shows model met assumptions of uniformity, and right panel displays model did not exhibit zero inflation.